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DIVISION OF ENTOMOLOGY

STUDIES ON THE HARLEQUIN BUG

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AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS

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BULLETIN NO. 227 APRIL, 1918

STUDIES ON
THE HARLEQUIN BUG

F. B. PADDOCK, M. S., ENTOMOLOGIST IN CHARGE; STATE ENTOMOLOGIST

INTRODUCTION

Almost every one in Texas who grows any garden is familiar with the insect known as the harlequin bug, often referred to as the fire bug, terrapin bug, and calico back. This insect seems to be present in almost every home garden and truck field in the State in which any cruciferous plants are grown. And, when present, it is such a serious pest that it is dreaded by those who know it. The climatic conditions of the State are favorable for the development of this insect. The mild winters result in a low mortality of the hibernating bugs. Since this insect is practically free from the attacks of the predaceous enemies and parasites, the control of its depends entirely upon the grower's effort.

The studies here recorded on the harlequin bug were started in the spring of 1915 by the writer. During the summer of 1916, cage notes were taken by O. K. Courtney, then Assistant Entomologist. Much credit is due H. J. Reinhard, Assistant Entomologist, for his painstaking work with the cage experiments while this project was in progress, and grateful acknowledment is hereby made.

HISTORY

This insect was first described by Hahn(1) in 1834 from material collected in Mexico, which material at that time was in his private collection in Germany. In spite of the fact that this species was first taken into Mexico, there seems to be some doubt that this country was the original home of this insect. In view of the fact that the remaining species of the genus are found in Central and South America and that later explorations show *histrionica* to be well distributed in these countries, it is safe to conclude that Central America was the original home of the harlequin bug, *Murgantia histrionica*, Hahn. The next mention of this species was in 1851, when it was listed by Dallas(2) in his "List of Hemiptera," then found in the British Museum. He reported four specimens, three of which were from Mexico, and the locality of the fourth was not given.

The occurrence of this insect in the United States was mentioned for the first time by Benj. D. Walsh(3) in 1866 in an article in "The Practical Entomologist," which incorporates the description of the injury of the insect by Dr. Gideon Lincecum, of Washington county, Texas. This accurate early account is herewith produced:

> "The year before last they got into my garden, and utterly destroyed my cabbage, radishes, mustard, seed turnips, and every other cruciform plant. Last year I did not set any of that order of plants in my garden. But the present year, thinking the bugs had probably left the premises, I planted my garden with radishes, mustard, and a variety of cabbages. By the first of April the mustard and radishes were large enough for use, and I discovered that the insects had commenced on them. I began picking them off by hand and tramping them under foot. By that means I have preserved my 434 cabbages, but I have visited every one of them daily now for four months, finding on them from thirty-five to sixty full grown insects every day, some coupled and some in the act of depositing their eggs. Although many have been hatched in the garden the present season, I have suffered none to come to maturity; and the daily supplies of grown insects that I have been blessed with are immigrants from some other garden.
>
> "The perfect insect lives through the winter, and is ready to deposit its eggs as early as the 15th of March, or sooner, if it finds any cruciform plant large enough. They set their eggs end to end in two rows, cemented together, mostly on the underside of the leaf and generally from eleven to twelve in number. In about six days in April—four days in July—there hatches out from these eggs a brood of larvae resembling the perfect insect, except in having no wings. This brood immediately begins the work of destruction by piercing and sucking the life-sap from the leaves; and in twelve days they have matured. They are timid, and will run off and hide behind the first leaf stem, or any part of the plant that will answer the purpose. The leaf that they puncture immediately wilts, like the effects of poison and soon withers. Half a dozen grown insects will kill a cabbage in a day. They continue through the summer, and sufficient perfect insects survive the winter to insure a full crop of them for the coming season.
>
> "This tribe of insects do not seem liable to the attacks of any of the cannibal races, either in the egg state or at any other stage. Our birds pay no attention to them, neither will the domestic fowls touch them. I have as yet found no way to get clear of them, but to pick them off by hand."

In his article, Walsh speaks of this insect as occurring in Texas and Louisiana.

The year 1864 is assumed as the date of the introduction of this species into the United States. This date, however, is the first record of the insect as a pest, at a point some distance from the Mexican border. The Mexican cotton boll weevil, even with its rapid spread was six years in getting as far from the Mexican border as the first locality given for the harlequin bug. Furthermore, the records made in 1864 in Washington county indicate that the pest had been present in that locality in vast numbers for some time. It was six years later before mention was made of this insect at Austin, in Travis county, eighty-five miles west of the first reported locality and no farther from the Mexican border. From this, it would seem that this pest crossed the border several years previous to 1864.

In January, 1870, C. V. Riley in "The American Entomologist" (4) recorded the presence of this insect from Salisbury, North Carolina,

Fig. 1.—Geographical distribution of the harlequin bug in North America. (Original)

and said: "It seems to be as great a pest in the gardens of that state as Dr. Lincecum describes is to be in Texas." In March of the same year, J. S. Stelle (5), of Tennessee, in the same publication recorded the date of occurrence of this insect in Georgia, Alabama and Mississippi, and gave a vivid account of the progress of the pest northward through these states into Tennessee.

In the following year Stal(7) listed this species in the present genus in his "Enumeratio Hemipterorum." The specimens were present in the museum at Stockholm, and the distribution was given as "Mexico, Texas and Louisiana."

Riley(8) again wrote on this insect in 1872 in his "Fourth Report." He said that prior to 1870 this species was not present in Missouri, but in the two years previous to his writing the harlequin bug had been found in some of the southern counties of that state, and in Kansas it had been found as far north as the latitude of St. Louis. He said that "this species now extends as far south as Guatemala."

In 1880, Godman and Salvin(10) discussed this species, carefully, giving synonyms, bibliography, distribution to date and, briefly, the main points of life history. The distribution included Arizona, California, Colorado, Delaware, Florida, Indian Territory, Louisiana and Texas; Oaxaca, Mexico; Capetillo, Duenas, Purula, San Geronimo, Guatemala; and Costa Rica. In the same year Lintner(11) told of the presence of this insect in Virginia. In his paper he warned the vegetable growers of New York to acquaint themselves of the appearance of this insect, so that they would be able to combat the pest when it arrived in that State. He expressed confidence that the pest would eventually reach New York, and finally spread over the entire state.

DISTRIBUTION

The year following the first report of this insect in Texas, it was reported from Louisiana by Walsh(3), although no localities were given by him. In the fall of 1867, Riley(4) reported the presence of this insect in Salisbury, N. C. Stelle(5) says that in 1867 this insect was found in the Carolinas near the Coast; at Macon, Georgia; Tuscaloosa, Alabama, and Columbus, Mississippi. In the fall of the following year he says that the fall brood appeared along the northern boundary line of Mississippi and Alabama. In 1869, Stelle recorded the occurrence of the harlequin bug at Humboldt and Nashville, Tennessee. Riley(8) tells of the presence of this insect in 1870 in the southern counties of Missouri and in Kansas as far north as the latitude of St. Louis.

Uhler(9) in his exploration trips through the western territories found this insect in the Indian Territory, Arizona, California, Nevada, and Colorado. In another paper Uhler said: "Its introduction has been effected since the late war (Civil War) and now (1875) it is known as far north as the vicinity of Pennsylvania boundary line in Delaware." By 1876 this insect was quite common in the Ohio counties adjoining the river. Specimens were sent to Lintner from Ivy Depot, Virginia, on September 24, 1880, but did not become abundant enough to cause extensive destruction of crops until 1894.

In 1889 this species was recorded at Las Vegas, N. M., where it was said to have existed "from the time immemorial." The first record of this insect in Indiana came in 1890. In New York it was not until 1894 that this insect attracted attention of the growers in the southern part of the state, but it was not until 1910 that isolated specimens were found as far north as Oswego, on Lake Erie. According to Webster this insect at one time reached as far north as Chicago, Ill., and almost to the shore of Lake Erie in Ohio. In 1910 specimens were also taken at Meridian, Conn., and in 1912 isolated specimens were again taken close to the shore of Lake Erie, after an absence in this locality of many years.

It is to be regretted that all of these early dates given do not represent the first appearance of the insect in the state. In fact, most of the early references are to the insect as a serious pest doing great damage. Every effort has been made to secure the exact date of the first appearance of this species in a state.

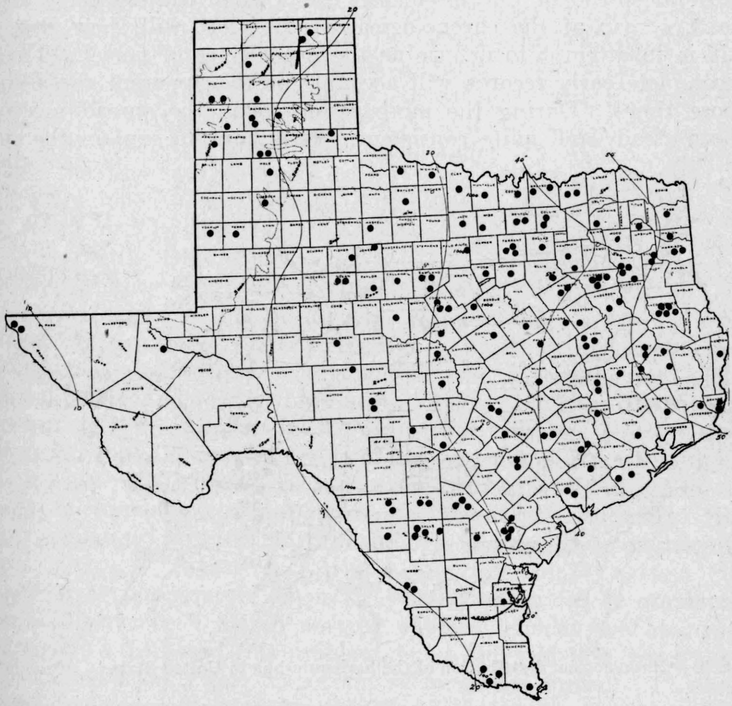


Fig. 2—Distribution of the harlequin bug in Texas. (Original)

An idea of the distribution of the harlequin bug can be had by reference to figure 1. In this no attempt has been made to show every locality in the United States where it is to be found at present. It will be observed that this species has been found over a range of from 10° to 43° 38′ N. latitude. The most southern locality was recorded in 1880, at which time the most northern place attained was 38° N. latitude.

The harlequin bug is now reported from the following states: Alabama, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, Georgia, Florida, Indiana, Kansas, Kentucky, Louisiana, Maryland, Mississippi, Missouri, Nevada, New Jersey, New York, New Mexico.

North Carolina, Ohio, Oklahoma, Pennsylvania, South Carolina, Tennessee, Virginia, and Texas.

Figure 2 gives the distribution of the insect in Texas as indicated by reports of injury that have come to hand. While the reports are most numerous from the eastern or humid section, it is evident that in this state the distribution of the pest is governed only by the distribution of its food plants.

DISPERSION

From the rather incomplete records available it is possible to trace the general spread of this insect over the United States. Reference to figure 3, a map of the chronological distribution, will show how difficult it is to attempt to determine the exact lines of travel. The fact of incomplete early records will account for the apparent rapid spread in those times. During the more recent years the spread northward has been steady and quite consistent. It is hard to explain the spread

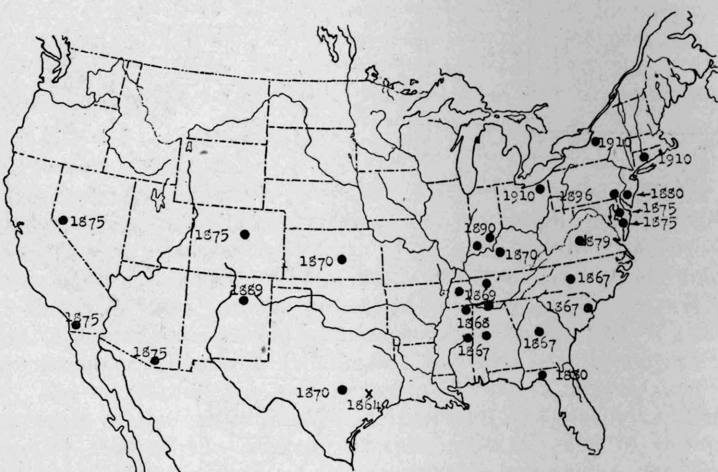


Fig. 3.—Chronological distribution of the harlequin bug in United States. (Original)

satisfactorily by what some writers term "commercial jumps." Such a spread is not wholly borne out by the facts of the life history, even though it might be accomplished. Stelle(4) as early as 1870 gave a very good account of the gradual northward spread of this insect. He said in 1867 it was present as far north as Tuscaloosa, Alabama, and Columbus, Mississippi. The fall brood of 1868 appeared along the Tennessee line. The next year both broods were abundant at this latitude and in the following year appeared as far north as Humboldt and Nashville, Tennessee. Between 1868 and 1869 the species spread northward for 50 miles.

The harlequin bug originated in the tropical life zone and no doubt came into the United States through that zone, which extends into Texas for a very short distance. Its early appearance in California and Arizona can be explained from the projection between these states for a very short distance of this zone from Lower California and Mexico. The spread in California was very slow, however, for as late as 1889 it was reported from only three counties. It has been supposed that this insect spread first over the lower austral zone. We find, however, early mention (1870) of its presence in Kansas in the upper austral zone, and as early as 1875 it was reported from Denver, Colorado, in the transition zone. The first reports from Mississippi, Alabama, and South Carolina in 1867 were from the lower austral zone. The report of the same year from Georgia came from the upper austral zone, and the locality in North Carolina for the same year was in the upper austral zone at the edge of the transition zone. The spread northward in Mississippi was through the lower austral zone, and in 1869 specimens were taken from Louisville, Kentucky, in the upper austral zone.

From that time, the spread was rapid along the Atlantic seaboard, following the line of the upper austral zone. This spread was separated from a much slower spread in the Ohio valley region by a projection southward by the transition and boreal zones. This insect appeared early in the Ohio counties bordering on the river, but the spread northward was very slow. For a time it appeared as though the insect had stopped along the line of division between the glaciated and unglaciated sections of the country. It was fourteen years later before a single specimen was found in the glaciated area, this being in Indiana. This insect was found in the three northernmost localities in 1910. In Connecticut the locality was in the transition zone; in New York, in the transition zone, at the very edge of the boreal zone; in Ohio, in the transition zone. This insect has not become permanently established as far north in New York as isolated collections would indicate. It is, however, gradually working northward, overcoming the climatic limitations.

The effect of temperature upon the spread of an insect of tropical origin has always been an interesting subject. Today we are somewhat inclined to disregard this problem, but a study of this insect shows that climate has been a very important factor in its spread. The early writers gave considerable study to the effects of climate upon a probable spread of this insect:

Stelle(5) said in 1870:

"So far, the change of climate does not seem to have affected this insect in the least,—it was as destructive and numerous along the southern line of Tennessee last summer as it had been previously at any point further south. A careful study of its character has warranted me in predicting that it will scarcely stop short of the Great Lakes."

In 1882 Lintner(10) said that since the species is a pest at Denver, Colorado, it "is capable of sustaining itself even north of the isothermal line of 40° Fahr. Allowing it this range will admit of its future extension into the western states, at least over the southern portion of Minnesota and Wisconsin, and eastward, entirely over the states of New York and Vermont, the southern portions of New Hampshire and Maine, a large portion of the province of Quebec. This extension, we believe, will be only a question of time, for its progressive march seems to be steady."

Contrary to these early predictions of the northward travel of this insect, since 1880 the spread has been very slow, and extremely cold winters have had a decided effect in preventing its spread.

In December, 1899, Webster(12) said:

"The harlequin cabbage bug, *Murgantia histrionica,* has certainly sustained a severe repulse by the low temperature of last winter. While the insect was observed in southern Ohio last May, its almost entire absence has been reported in localities where last year it was disastrously abundant. From this it would appear that only the most hardy or best protected individuals have survived in Ohio, and we may now look for it to attempt again to push its way northward until it is once more driven back by adverse meteorological conditions."

Again in 1901(13) he said: "The harlequin cabbage bug, which was exterminated by the severe winter a few years ago, has begun its northward spread again, and has been reported as destructive at points along the Ohio river." The insect was exterminated the same year in Maryland and Delaware and was not found in that territory again, even in the isolated colonies, until 1908. At this latitude the insect is a pest of cultivated crops only after a very mild winter. Even now it may be found late in the fall on some wild food plants.

Sanderson(14) considers the harlequin bug as one of the insects whose distribution is considered as more or less controlled by minimum temperature. He says: "The northern limit of this species follows the average annual-minimum isotherm of 0° G. much more closely than the upper austral zone. It may yet migrate to northern Ohio and Ontario, but further progress seems doubtful."

SCIENTIFIC NAME

Hahn(1) in 1834 described the harlequin bug as *Strachia histrionica,* a genus which has been established for several years. In 1851 Dallas (2) listed this species without any change, although he did revise and establish synonyms for other species. The first reference to this species in American literature was by Walsh(3), when he placed the insect in the family *Scutelleridae* of the order *Heteroptera.* Following in 1870, Riley(4) called the harlequin bug *Strachia histrionica,* as did Stelle (5) in another reference to the species in the same year.

In 1867 Stal erected the genus *Murgantia* and in his work (7) in 1871 he placed this genus in the sub-family *Pentatomina,* also erected by him, and in the family *Cimicina* erected by him, in a section called "Enumeratoio Cimicinorum Americae." He placed *histrionica,* Hahn, as the only example of a division of the genus, "aa. *Antennis brevibus;*

Thorace margineum auticum punctis absiletis serioposítis instructo margine ioso calloso, elevalo; corpore subtus nigro, maculis alhidis et croceis in series dispositio ornata."

Evidently the work of Stal was received promptly in the United States, for Riley(8) in 1872 gave the scientific name as *Strachia* (*Murgantia*) *histrionica,* Hahn. The name, *M. histrionica,* Hahn, has been accepted by all writers since that time. Lintner(11) in 1882 placed this insect in the family *Cyanidae* of the sub-order *Heteraptera.* Later it was placed in the family *Pentatomidae,* where it now stands.

ALLIED SPECIES

Stal in his work in 1867 listed a species *M. munda* Dallas, which was named by Dallas in his work in 1851. Stal places *munda* in another division of the genus *Murgantia,* characterized in distinctions as follows: "a, *Antennis longis; thorace propemargineum anticum punctato, hoc margine land vel vit elevato; corpore subtus flavescute, maculis lateralibus caerleis vel vislaceis."* This species is listed from Mexico and Columbia.

Riley(8) in 1872 said:

> "It (the harlequin bug) varies very much, as most species are found to do when their geographical distribution is studied. As it extends southward we find the dark colors predominating and becoming more intensified and brilliant, and described a species (*Murgantia munda*) from Mexico, which is doubtless but a geographical race, since all the intermediate grades occur between it and the more northern form of *histrionica.* My friend, P. R. Uhler, has made some interesting experiments on the species, which have clearly proven that when reared in the dark the pale red parts predominate; while if reared in the bright daylight, the dark blue colors predominate."

On this same matter Distant(10) in 1880 quoted further from Uhler as follows: "Several of the links in the chain of varieties between this species *histrionica* and *M. munda* have already been found, and we may expect hereafter to see the two species united as mere forms of one." Speaking further, Distant said: "We ourselves, however, have seen nothing as yet to warrant such a probability. The specimen figure is from Guatemala, and, excepting slight variations, is the dominate form in Central America. Hahn's figure would seem to represent a melanic and (judging from my own experience) scarce form of this species."

Notwithstanding these opinions, we find that in 1891, in "Insect Life," we have received specimens from California, which are probably *Murgantia munda.* Since the time of Uhler's quotation there has been no reference to *munda* and it is quite possible that later studies have convinced entomologists that there was insufficient reason for maintaining two species, regardless of the fact that Stal considered them anatomically separated. Any extended study of this species will reveal that the color variation is very considerable and is not constant. In addition, there is a seasonal variation; the fall brood is much darker than the spring and summer broods.

Riley(8) mentions the presence in Europe of *Murgantia* (*Strachia*) *ornata* Linn, a species "which bears a striking resemblance to our insect in color and ornamentation, and which, as I was assured by M. E. Mulsant, of Lyons, France, has the light parts red in spring and yellow in autumn." This insect is a serious pest of cabbage.

COMMON NAME

In 1866 Walsh(3) wrote of the insect as the Texas cabbage bug. In 1870 Riley(4) said: "Hitherto it had been generally supposed by entomologists that the harlequin cabbage bug was confined to the most southerly of the southern states, such as Texas and Louisiana, and it has been called by some 'The Texas cabbage bug,'" instead of translating the scientific name and calling it as we have done, the "harlequin cabbage bug." This so-called translation seems a little arbitrary, although the word harlequin (gay colored) describes the insect very well. *Histrionica* is undoubtedly derived from *histrio,* meaning actor. Of late years there has been a tendency to say merely harlequin bug, as the insect attacks a wide variety of plants and its chief injury is not always to cabbage. Especially is this true in Texas where winter crops of collards, mustard, and turnips are often destroyed by this insect. It is known locally as the collard bug, terrapin bug, calico bug and fire bug.

ECONOMIC IMPORTANCE

Most of the early writers did not fail to impress on their readers the great destruction accomplished by this insect. The original discussion by Dr. Lincecum mentions the "utter destruction of cabbage, radish, mustard and turnip,—finding from 35 to 60 full grown insects on every, plant." Riley in 1870 said that in North Carolina it seemed to be as great a pest as in Texas. And he quoted from B. R. Townsend, Austin, Texas, "Within a few days he had gathered, by hand, 47,000 bugs." Stelle in 1870 said: "Last year it worked wholesale destruction." Lintner said in 1881: "This insect entirely destroyed the cabbage crop in a section in Virginia. Its distribution over the northern portion of the United States cannot but operate as a serious check upon the culture of cabbage." Between 1892 and 1893 this insect was a very destructive one in cabbage fields in Delaware.

In Texas where the mild winters do not serve as a substantial check, this pest causes much damage every year to all of its cultivated host plants. In most sections the home gardens suffer severely from the attacks of the insect, and in truck regions unlimited damage is done.

FOOD PLANTS

From the name commonly applied to this insect it might be inferred that cabbage was a primary food plant. The harlequin bug, however, feeds upon many members of the *Cruciferae* family, not only the cultivated but some of the wild species. As the insect advanced northward, it was always feared as a cabbage pest, for in new territory its work seemed to have been most apparent on this host. Even now in the northern section of its range, this insect does most damage to cabbage. Throughout the South it is very destructive to winter truck crops of turnips, mustard, and collards. The feeding of the harlequin bug is not confined to the *Cruciferae* but it has a wide range of host plants.

The following plants have been observed to serve as food plants for the harlequin bug in Texas: *Amaranthus spinosis,* cabbage, cauliflower, citrus (orange, grape fruit and loquet), collards, corn, cotton, egg plant, grapes (cultivated), kale, kohlrabi, lettuce (cultivated), mustard, nasturtiums, okra, cowpeas, pepper grass (Lepedim), rag weed (*Ambrosia sp.*), rape, rock cress (*Arabis ludaviciana* Hork), rutabaga, and squash.

Amaranthus spinosis serves as a host of this insect in July at a time when there are almost no succulent plants in this vicinity. Cabbage is attacked at any time that it is available in the fields, which is also true of cauliflower. The feeding on citrus is largely confined to the fall; the very ripe fruits are attacked, especially if the skin is broken. Collards are subject to attack during the fall, winter and early spring; this plant often serves as a winter host of the insect. In July the insects were very numerous on corn, all stages and eggs being observed on this plant. Cotton is attacked during August and September at a time when few vegetables are succulent. The bugs pierce the medium-sized bolls, which does not seem to prevent the latter from opening. Egg plant is seldom attacked, but all stages of the insect have been taken upon this plant. Grapes seem to be attacked only after the favorite food plants have been destroyed in June. Kale is not preferred and is attacked in the late spring only after mustard and collards are no longer available. Kohlrabi is not readily attacked and for that reason the plants are seldom entirely destroyed. Lettuce is attacked in the spring only after the favorite food plants have been destroyed. Mustard is readily attacked, especially in the spring. Only one instance is recorded of the cabbage bug feeding on nasturtiums and this was after turnips in an adjoining patch had been destroyed. Okra serves for feed only at times during the summer; eggs have not been found on this host. Throughout the month of July the harlequin bug feeds on cowpeas. Eggs are also deposited on this host. Pepper grass was observed to serve as a host in March, at which time cabbage was also available in the same garden. The insects seemed to prefer this host to all others at that time. Radishes are attacked any time they are available and the crop is readily destroyed. Rape serves as a food plant only after the favorite food plants are destroyed. In the early spring the cabbage bug is observed feeding on the rock cress, although only for a limited period, and no eggs were found on this host.

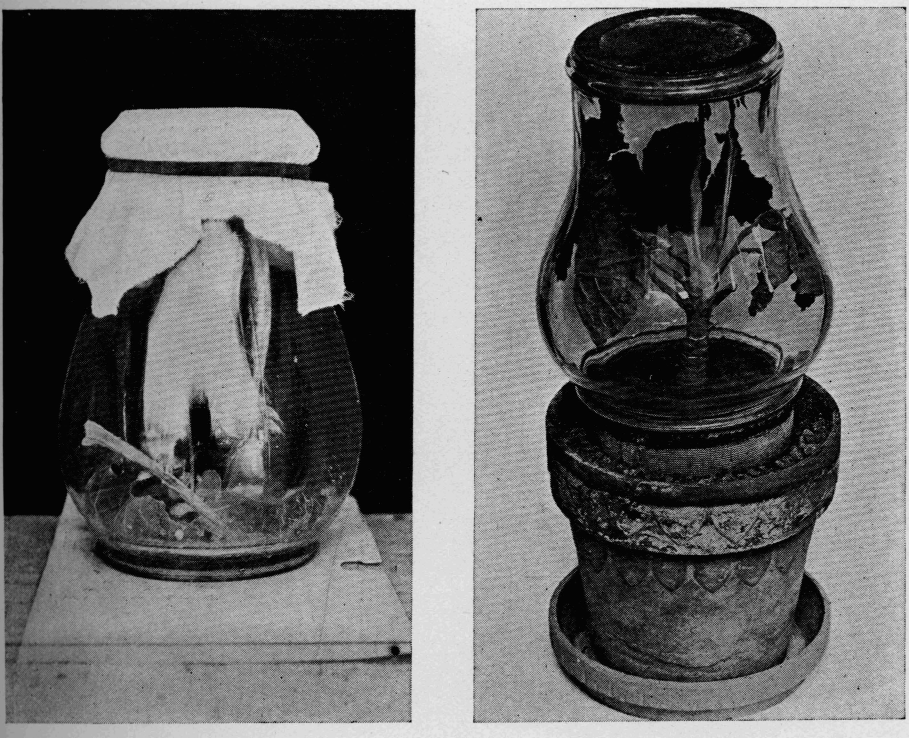
Rutabaga turnips are not readily attacked, except in the absence of a favorite host. In the early fall the bugs have been found feeding on squash but no eggs have been found deposited on this plant. Turnips are readily attacked at any time.

In addition to the host plants listed above for Texas, Garman says wild mustard serves as a host in the early spring. Webster reports the cabbage bug feeding on horse radish. Chittenden records asparagus, potatoes, tomatoes, beans and beets as plants that may be attacked. Damage may also be done to roses, sunflowers and chrysanthemums. Cherry and plum have served as food for the bugs. Pig weed (*Amaranthus sp.*), wild lettuce (*Lactuca canadensis*), and lamb's quarter (*Chenopodium sp.*) serve as food plants for the harlequin bug. It is also possible for this insect to breed on any of these weeds.

METHODS OF STUDY

For the purpose of observing the details of the life history of the harlequin bug, specimens were isolated in cages. The type of cage first used in this work is shown in plate 1, (a) a lantern globe with a cover of cheese cloth. In this cage, fresh food was placed daily, which usually consisted of collard leaves or cabbage leaves, taken from the growing plants in the field when possible. This method of supplying fresh food to the bugs required the transferal of them each day on to the fresh food. During the summer season, the food would not remain in good condition as long as twenty-four hours. For this reason, the use of this type of cage was not wholly satisfactory. Later, a new type of cage, plate 1 (b), was adopted for the life history studies. This cage consisted of a large street lamp globe No. 3. On the bottom of this is a tight collar made of a two-inch strip of brass screening; the top is made of similar material. This cage allows a free circulation of air over the food material, which keeps it in good condition for a considerable period of time. To avoid the transferal of the bugs each day, growing plants in eight-inch pots were used. These plants were usually collard, although some cabbage plants were used. The larger leaves were trimmed off so that the plant would fit well into the cage. The plants were kept in excellent condition and usually a single plant served to mature a generation of bugs. The hatching egg masses were placed on these plants and the bugs were observed throughout the duration of their lives. By daily observations it was very easy to determine the moults of the immature bugs and the daily egg deposition of the mature bugs. All of the cages were kept in the shelter shown in plate 2.

For seasonal history observations two types of cages were used. The large cage shown in plate 3 is 4 feet by 6 feet by 6 feet, covered with wire screening, and built so as to be taken apart in sections. The cage was placed over several kinds of plants to determine the preference, if any, of the hosts during the year. Another cage of the same type was used for general hibernation studies. The cages shown in plate 4 were used for special field observations of the life history, particularly hibernation studies. The woods shown in the distance served as natural hiberating quarters for the harlequin bug. This allowed extensive notes to be made under actual field conditions to serve as a check on the cage notes.



(a) (b)

Plate 1.—(a) Type of rearing cage first used; (b) type of cage adopted for all life history experiments. (Original)

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LIFE HISTORY

The life history of the harlequin bug has been mentioned by a number of the early writers in a more or less indefinite way. Dr. Lincecum in his early account of this insect gives several very interesting observations, such as the number of broods, the hibernation, and the length of the egg stage. Most writers have quoted these observations and added a few local notes, in an effort to outline the details of the life history. Among the more recent publications are the papers by Smith that give the results of his experiments, which consist of the detailed observations of the life history of the insect.

In our work we have arbitrarily set dates which have assumed the natural divisions of the broods during the year. There is, of course, a very considerable overlapping of the broods during the year, but detailed cage studies have enabled us to arrive at the actual number of broods during the year. We designate the Spring brood as those insects that develop from eggs hatched before June 1; the Summer brood, those insects which develop from eggs hatched from June 1 to August 15; the Fall and over-wintering brood, those insects hatching from eggs deposited from August 15 to October 15. Most observations have shown that eggs deposited after September 15 will not always develop into mature bugs, which are the only ones that can successfully pass the winter.

EGGS

The egg is cylindrical and rounded on both ends. When first deposited, the eggs are a light green in color but soon become white with black markings. Running around the egg are two black bands, the one near the top being about twice as wide as the one near the bottom. Just above the lower band is one black spot. On the top end of the egg is a black crescent which borders a slightly depressed lid. This crescent extends half around the lid, being always on the outer side of the egg mass. There are no markings on the lower end of the egg which is much rounded, whereas the top is much flattened. When first deposited the eggs are covered with a glue which fastens the egg to the leaf and to the adjoining eggs. After drying the eggs are very hard and the dry mass can be loosened from the leaf, but it is very difficult to separate the individual eggs. The average size of the eggs is 75 mm. long and 1.25 mm. wide. Plate 5, (a) shows an egg mass of the harlequin bug.

HATCHING

The process of hatching attracted attention of the investigators as early as 1872. Previous to hatching, the egg loses the pearly white color and appears yellow to orange from the developing bug. The young insect cuts the shell in the upper end of the egg at the outer edge of the black crescent. This cut is very smooth and accurate and extends only slightly beyond the length of the crescent. Thus a lid to the egg is formed by the portion remaining uncut. The young insect emerges from the egg dorsal side outward. There seems to be much resistance in that portion of the shell which is uncut and the insect apparently has to "squeeze" out of the opening with much effort. Emergence is accomplished, with the exception of the tip of the abdomen, which is held firmly by the shell, thus holding the insect in an erect position. It remains in this position for some time while the parts harden, which enable it to move off. The batch of eggs hatches irregularly, which allows freedom to the young bugs in drying. One bug is drying and moving off before the adjoining egg hatches. From the time the shell is cut until the young bug is dry, all the time of hatching, is about forty minutes. After hatching, the young remain clinging to the sides of the egg shells, as shown in plate 5 (b), for about thirty-six hours before moving off onto the plant for feeding.

INCUBATION PERIOD.

The period of incubation varies greatly with the brood and seasons in proportion to the fluctuations in temperature. The effect of humidity upon the incubation period has not been determined but as it is recorded, it is given in the tables. The recent papers on the effect of the humidity on insect metabolism seem to indicate that this factor can be disregarded in insect studies. The low temperature at which the vitality of the eggs is destroyed has not been determined.

In the following tables the maximum is the highest single temperature during the period; the minimum is the lowest single temperature during the period.

The mean given in the tables is the average of the mean daily temperature of the days in the period. The determination of the length of the period has been made by placing the freshly laid eggs with a piece of leaf on which they were deposited in a small lantern globe cage. The cages were kept under natural conditions which were recorded by the hydro-thermograph.

Spring Brood

Table 1.—Duration of egg stage, brood, 1915.

Laid.	Hatched.	Days.	Temperature.			Humidity.		
			Max.	Min.	Mean.	Max.	Min.	Mean.
1915	1915							
Mar. 12	April 9........	28	87	34	54.7	100	26	70.5
15	10........	26	87	34	56.6	100	26	73.4
17	12........	26	87	34	58.4	100	26	73.9
30	16........	17	87	34	62.3	100	26	69.4
April 5	16........	11	85	55	70.3	100	30	72.2
7	17........	10	85	55	71.2	100	30	71.4
8	19........	11	85	54	70.7	100	30	70.8
11	21........	10	85	54	70.7	100	30	73.2
12	22........	10	85	54	70.6	100	30	74.1
19	29........	10	83	57	70.9	100	63	89.7
20	30........	10	86	57	71.8	100	63	90.2
21	May 1........	10	86	61	71.9	100	63	89.2
22	2........	10	86	61	71.9	100	64	90.1
26	3........	7	86	66	74.9	100	64	89.2
27	6........	9	86	61	72.6	100	64	86.1
29	8........	9	86	60	72.1	100	64	86.3
May 4	23........	19	92	53	75	100	33	75.2

The longest period of this brood in 1915 was 28 days with a mean daily temperature of 57° F.; the shortest period for this brood was 7 days with a mean temperature of 74.9° F.; the average period of this brood was 13.7 days with a mean daily temperature of 68.6° F.

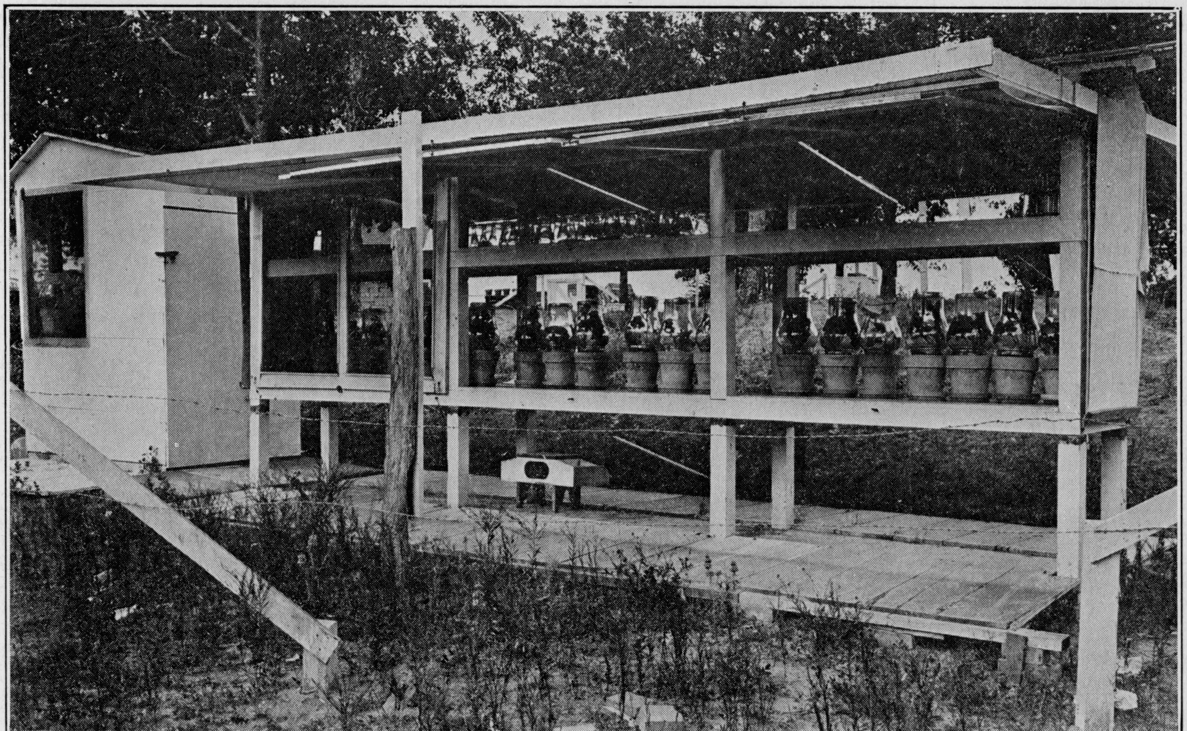

Plate 2.—Cage shelter where the life history observations were made. (Original)

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Table 2.—Duration of egg stage, brood—1916.

Laid.	Hatched.	Days.	Temperature.			Humidity.		
			Max.	Min.	Mean.	Max.	Min.	Mean.
1916	1916							
Feb. 2	Feb. 26	24	89	25	55.9	100	22	67.5
28	Mar. 6	7	89	37	59.7	100	26	53.8
28	14	14	89	37	63.3	100	12	63
Mar. 1	10	9	89	37	55.9	100	12	63.5
6	14	8	89	54	71.1	99	12	63.5
9	20	11	89	44	65.7	98	22	59.2
14	23	9	94	44	68.4	98	22	61.2
23	April 4	12	89	41	68.3	100	17	63.5
25	Mar. 30	5	89	41	65.2	100	18	59.1
25	30	5	89	41	65.2	100	18	59.1
27	April 12	16	89	31	63.5	99	18	66.7
27	12	16	89	31	63.5	99	18	66.7
April 5	18	13	89	31	65.6	100	22	70.3
6	18	12	89	31	65.7	100	22	79.9
11	20	9	90	31	71.6	100	30	69.7
14	23	9	90	50	62.8	100	19	66.6
15	23	8	90	50	72.8	100	19	66.3
18	25	7	90	50	72.8	98	19	62.7
23	May 4	11	91	47	68.2	99	22	71
May 1	9	8	90	53	70.1	99	30	74
3	9	6	90	53	70.6	97	30	70.7
8	13	5	94	69	80.3	98	35	66.1
10	17	7	94	59	81	97	30	66.8
13	20	7	92	56	74.8	100	31	68.8
14	22	8	92	56	73.8	100	30	71.8
24	29	5	92	68	80.8	98	42	74.9
31	June 5	5	98	46	72.1	98	39	68.8

The longest period of this brood in 1916 was 24 days, with a mean temperature of 58.9° F.; the shortest was 5 days, with a mean temperature of 72.7° F. The average period of this brood was 9 days, with a mean temperature of 68.9° F.

Table 3.—Duration of egg stage, brood—1917.

Laid.	Hatched.	Days.	Temperature.			Humidity.		
			Max.	Min.	Mean.	Max.	Min.	Mean.
1917	1917							
Mar. 10	Mar. 23	13	99	49	71	98	17	65.4
13	25	12	99	49	71.4	96	17	61.2
17	29	12	98	49	71.8	95	12	55.4
17	31	14	99	49	72.5	95	12	53.3
18	29	11	99	49	72.9	95	12	55.3
22	29	7	99	50	76.4	95	12	53.3
23	April 1	9	99	50	73.8	95	12	54
25	5	11	99	42	73.5	96	12	54.4
25	6	12	99	42	71.9	96	12	54.4
25	7	13	99	42	70.5	96	12	53.9
27	1	5	99	50	76.5	94	16	51.4
29	10	12	99	41	58	96	18	57.9
29	11	13	99	41	66.4	96	18	59.5
30	14	15	99	41	65.8	97	18	59.7
April 1	15	14	84	41	62.7	97	18	59.5
2	15	15	78	41	61.5	97	18	59.1
3	18	15	82	41	63	97	18	65.0
5	19	14	82	41	64.2	97	18	62.6
6	19	13	82	41	64.8	97	18	62.5
10	22	12	82	47	68	97	29	67.4
11	21	10	82	49	69.1	97	30	68.6
14	25	11	84	49	69.9	95	20	65.4
15	24	9	84	49	70.7	95	20	66.1
15	25	10	84	49	70.8	95	20	65.1
17	26	9	84	56	72.3	95	20	65.5
17	27	10	87	56	72.4	95	20	65.8
19	27	8	87	56	71.4	95	20	64.2
20	29	9	87	58	72	96	20	64.2
21	29	8	87	58	72.2	96	20	62.6
23	May 2	9	87	50	73.9	96	20	65
24	2	8	87	50	74.4	96	20	65.8
24	2	8	87	50	74.4	96	20	65.8

Table 3.—Duration of egg stage, brood—1917—continued.

Laid.	Hatched.	Days.	Temperature.			Humidity.		
			Max.	Min.	Mean.	Max.	Min.	Mean.
1917								
April 27	4........	7	87	50	73.3	96	24	66.1
27	8........	11	92	46	70.7	98	20	66.9
28	11........	13	92	46	67.1	98	22	66.4
May 1	15........	14	92	46	64.4	98	22	67.8
1	16........	15	92	46	64.6	98	18	66.7
6	18........	12	82	46	62.5	98	18	68.9
6	19........	13	82	46	63.4	98	18	69.1
11	21........	10	87	53	69.3	95	18	66.9
11	21........	10	87	53	69.3	95	18	66.9
13	22........	9	87	58	70.8	95	18	65.9
15	23........	8	87	53	72.5	95	18	64.3
18	25........	7	87	55	74.3	95	32	66.7
18	26........	8	90	55	75.1	95	32	68.8
21	28........	7	91	55	76.6	95	32	69.6
22	29........	7	91	55	76.4	95	20	63.8
23	29........	6	91	55	76.4	92	32	63.8
25	June 1........	7	94	57	79	95	20	64.2
26	May 31........	5	91	57	77.6	98	20	63.2

The longest period of this brood in 1917 was 15 days, with an average mean temperature of 64.5° F.; the shortest was 7 days, with an average mean temperature of 76.4° F. The average period of this brood was 11 days, with an average mean temperature of 72.3° F.

Table 4.—Period of incubation, spring brood.

Year.	Mean temperature, degrees F.	Duration, days.
1915....................................	68.6	13.7
1916....................................	68.9	9.0
1917....................................	72.3	11.0

Table 4 gives the summary of the period of incubation of the Spring brood of *M. histrionica* over the three years of observations. The records given show an average duration of this stage of 11.2 days, with a mean daily temperature of 69.9° F.

Summer Brood

The period of incubation of the Summer brood is somewhat shorter than that of the Spring brood on account of the great increase in the prevailing mean temperature. The length of this period is not as variable within the season, or from year to year, as is that of the Spring brood.

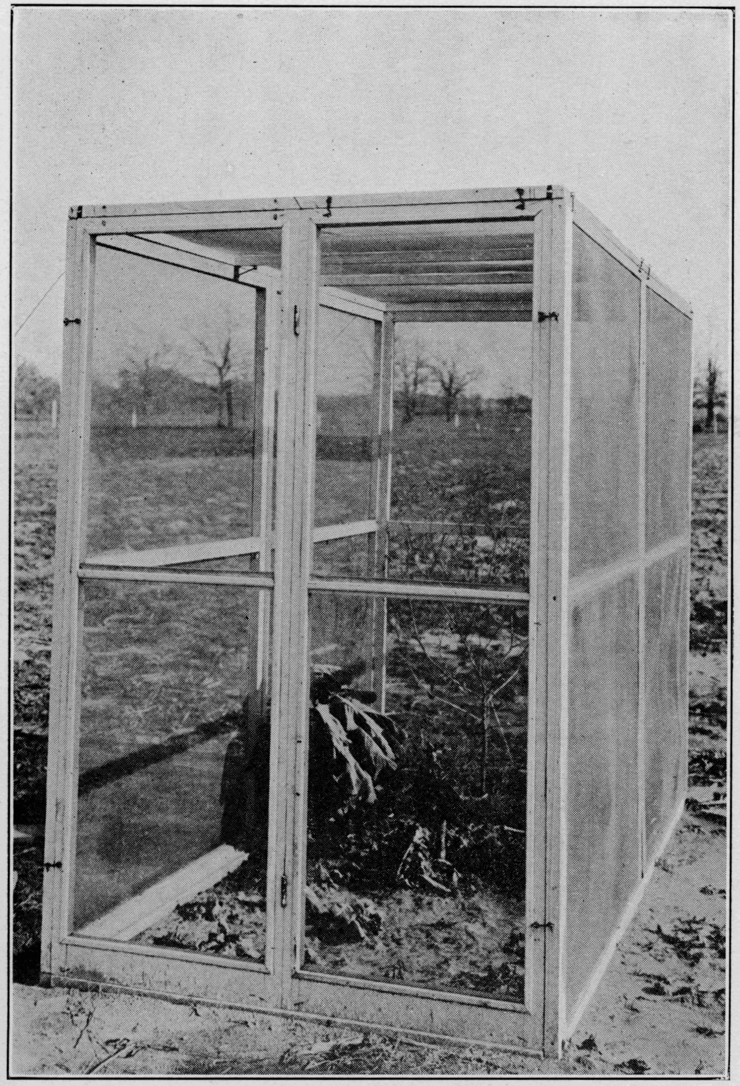

Plate 3.—Type of large outdoor cage used in seasonal history observations. (Original)

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Table 5.—Duration of egg stage, brood—1915.

Laid.	Hatched.	Days.	Temperature.			Humidity.		
			Max.	Min.	Mean.	Max.	Min.	Mean.
1915	1915							
June 19	June 24	5	97	70	84.2	100	43	73.2
21	25	4	97	70	84.4	100	43	72.5
24	29	5	98	74	86	100	32	71.9
26	July 1	5	101	73	86.6	100	32	69.5
27	2	5	101	73	86.8	100	32	67.3
30	6	6	98	72	80.5	100	35	72.5
July 1	7	6	98	70	78.7	100	41	74.1
4	8	4	95	70	81.8	100	51	75.3
6	11	5	96	70	80.5	100	44	74.4
8	13	5	99	74	81.7	100	44	73
11	15	4	99	73	82.4	100	39	71.3
13	18	5	99	72	83	100	38	68.3
24	29	5	99	63	86.1	100	37	67.9
28	Aug. 2	4	102	71	87	99	37	69.3

The longest period of incubation of this brood was 6 days, with a mean daily temperature of 79.6° F.; the shortest period was 4 days, with a mean daily temperature of 82.9° F. The average period for this brood for this year was 4.8 days, with a mean daily temperature of 83.5° F.

Table 6.—Duration of egg stage, brood—1916.

Laid.	Hatched.	Days.	Temperature.			Humidity.		
			Max.	Min.	Mean.	Max.	Min.	Mean.
1916	1916							
June 1	June 4	3	95	73	83.6	98	46	69
2	8	6	95	66	83.6	99	43	70.1
2	9	7	95	64	81.5	99	43	72.1
5	12	7	95	64	79.7	99	43	73.1
8	17	9	94	64	78.6	98	41	71.5
9	15	6	94	65	81.1	98	41	70.4
12	18	6	94	67	79.7	98	42	73.9
12	18	6	94	67	79.7	98	42	73.9
12	19	7	95	67	80	98	42	73.4
13	20	7	95	67	79.7	98	38	72.5
16	20	4	95	67	80.2	98	38	71.1
17	22	5	97	69	82.6	98	38	69.7
18	24	6	98	70	84.3	98	38	70.2
18	22	4	97	70	83.2	98	38	69
19	24	5	98	70	85	98	38	70
20	25	5	98	73	85.6	98	40	70.7
22	24	2	98	76	86.5	95	43	72.2
22	28	6	99	74	86.5	98	38	69.5
23	27	4	98	74	85.7	98	38	70.6
24	28	4	99	74	86.5	98	38	68.1
24	29	5	99	68	86.3	98	38	68.2
25	30	5	99	68	85.2	98	39	68.1
25	30	5	99	68	85.2	98	39	68.1
25	July 1	6	99	68	84	98	39	68.4
28	4	6	94	68	81.9	97	40	73.1
29	5	6	96	69	81.7	97	44	74.8
30	6	6	96	69	82	97	44	74.2
30	6	6	96	69	82	97	44	74
July 3	8	5	98	69	84	97	38	70.8
4	9	5	101	69	85.4	97	37	67.3
4	9	5	101	69	85.4	97	37	67.3
3	8	5	98	69	84	97	38	70.8
5	10	5	101	72	86	97	35	66.9
7	11	4	101	72	87.4	97	27	63.5
9	14	5	103	72	86.9	97	27	64.5
10	15	5	103	72	86.6	97	27	64.7
11	16	5	103	72	86	97	32	66.2
14	20	6	102	73	86	97	33	66.7
15	20	5	102	73	87.3	97	33	66.8
15	21	6	102	73	87.7	97	33	67.5
17	22	5	102	74	88.7	97	33	67.5
18	22	4	102	74	88.8	97	35	70.7
18	23	5	102	74	87.9	98	35	71.4
19	24	5	102	74	87.3	98	36	71.8
21	24	3	102	74	86.2	98	37	73

Table 6.—Duration of egg stage, brood—1916—continued.

Laid.	Hatched.	Days.	Temperature.			Humidity.		
			Max.	Min.	Mean.	Max.	Min.	Mean.
1916								
July 21	26	5	102	74	86.2	98	34	69.4
22	27	5	100	73	85.5	98	34	69.8
23	28	5	100	73	85.6	98	34	70.2
25	31	6	100	73	84.5	98	34	71.7
27	Aug. 1	5	98	73	84	97	40	72.5
29	4	6	99	73	83.4	99	37	69.1
31	4	4	99	73	85.7	99	37	67.4
Aug. 1	6	5	99	73	88.2	99	37	67.6
1	7	6	99	73	86.5	99	37	70.5
1	8	7	99	73	86.1	99	37	70.8
2	7	5	99	73	86.7	97	38	71.4
4	9	5	98	73	85.6	97	40	73.4
5	10	5	98	73	82.7	96	40	75.1
5	10	5	98	73	82.7	96	40	75.1
8	13	5	98	74	85.1	96	43	70.6
8	13	5	98	74	85.1	96	43	70.6
8	14	6	98	73	85.2	96	39	69.9
9	14	5	98	73	85.2	96	39	69.9
11	17	6	98	73	85.6	96	36	68.1
12	17	5	98	73	89.8	96	36	67.3
14	19	5	98	69	84.8	96	36	68.1

The longest period of incubation of this brood for this year was 7 days, with a mean daily temperature of 81.0° F.; the shortest period was 3 days, with a mean daily temperature of 86.2° F. The average period of this brood was 5.3 days, with a mean daily temperature of 84.6° F.

Table 7.—Duration of egg stage, brood—1917.

Laid.	Hatched.	Days.	Temperature.			Humidity.		
			Max.	Min.	Mean.	Max.	Min.	Mean.
1917	1917							
May 27	June 1	5	94	57	62.2	95	20	62.6
28	2	5	94	57	79	95	29	60.5
28	2	5	94	57	79	95	29	60.5
29	3	5	94	58	81.4	95	29	61.9
29	3	5	94	58	81.4	95	29	61.9
31	5	5	95	68	83.4	95	33	63.5
31	5	5	95	68	83.4	95	33	63.5
June 1	6	5	95	68	83.1	95	33	63.2
2	8	6	95	68	62.8	95	33	63.4
3	9	6	95	68	82.3	95	33	64.3
5	10	5	95	72	83	98	36	64.5
7	12	5	99	74	86.5	93	26	59.5
8	13	5	100	74	87.2	93	26	60.7
8	13	5	100	74	87.2	93	26	60.7
10	16	6	100	64	85.3	94	26	57.8
11	17	6	100	61	83.7	94	19	54.8
11	17	6	100	61	83.7	94	19	54.8
11	18	7	100	61	82.2	94	19	53.4
11	18	7	100	61	82.2	94	19	53.4
13	20	7	100	60	79.3	94	19	52.1
13	20	7	100	60	79.3	94	19	52.1
15	21	6	96	60	76.5	95	19	50.2
17	22	5	97	60	78.1	95	20	54.9
17	23	6	99	60	79.3	95	20	55.5
19	24	5	99	62	82.3	95	21	58.1
20	25	5	99	63	83.8	95	21	59
21	26	5	99	70	84.6	95	21	59.8
22	27	5	99	70	83.9	94	21	60.5
22	28	6	99	68	83.6	94	21	60.1
23	28	5	94	63	83.8	95	21	59
24	29	5	98	68	83.7	94	21	60.5
25	30	5	98	68	83.4	94	25	60.8
25	July 1	6	100	68	87.3	94	25	60.3
27	2	5	101	68	84.8	92	23	57.9
27	2	5	101	68	84.8	92	23	57.9
28	3	5	101	70	85.6	92	23	57.9
29	5	6	101	70	85.2	95	23	57.9
30	5	5	101	70	85.4	95	23	48.1

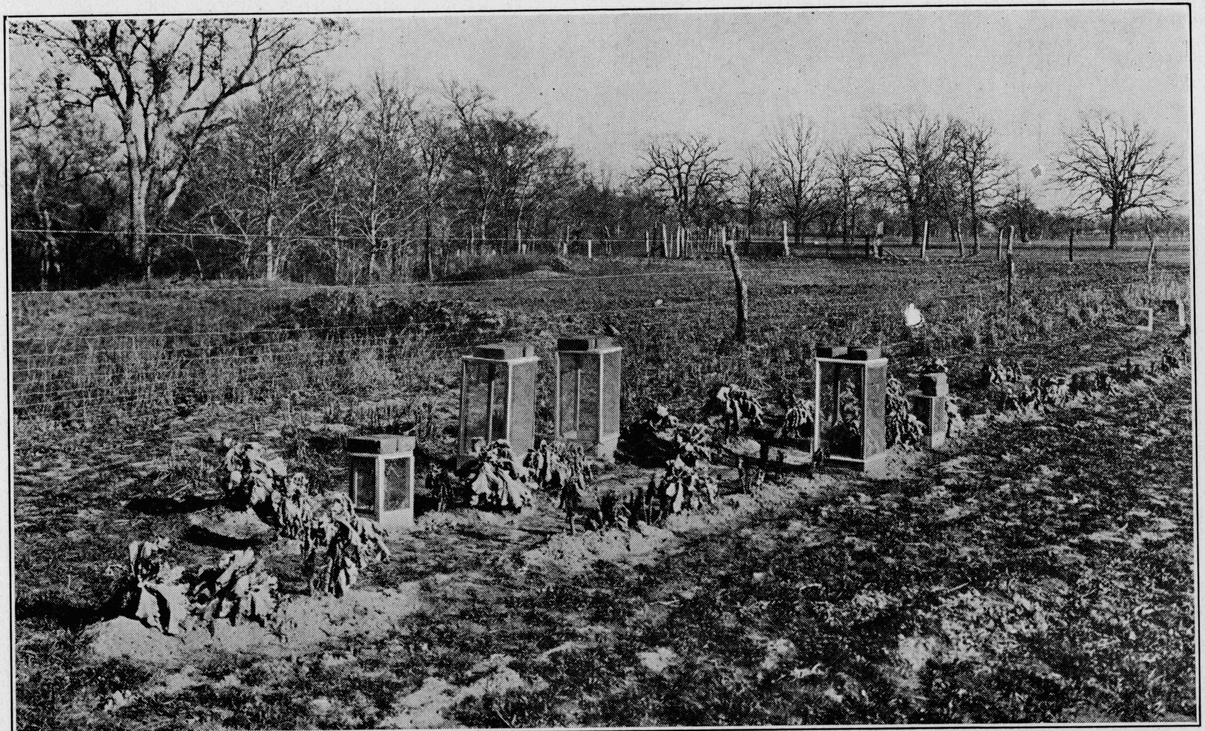

Plate 4.—Cages used in hibernation studies. Natural hibernation quarters in background. (Original)

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Table 7.—Duration of egg stage, brood—1917—continued.

Laid.	Hatched.	Days.	Temperature.			Humidity.		
			Max.	Min.	Mean.	Max.	Min.	Mean.
1917								
July 1	6	5	101	68	85.6	95	23	59
1	7	6	101	68	86	95	23	59.3
3	8	5	101	68	86.1	95	27	61.2
4	9	5	101	68	85.9	95	27	61.9
4	9	5	101	68	85.9	95	27	61.9
8	14	6	108	71	91.9	93	23	55.5
8	14	6	108	71	90.2	93	23	55.5
12	15	3	108	73	90.8	94	24	59.8
14	18	4	102	74	87.9	95	29	61.9
14	21	7	102	69	87.3	95	29	63.3
28	Aug. 2	5	99	43	82.5	97	23	63.5
31	6	6	100	71	85	95	27	61.1
Aug. 1	8	6	100	69	84.4	95	27	60.7

The longest period of incubation of this brood for this year was 7 days, with a mean daily temperature of 82.0° F.; the shortest period of this brood was 3 days, with a mean daily temperature of 90.8° F. The average period of this brood was 5.4 days, with a mean daily temperature of 82.8° F.

Table 8.—Duration of egg stage, summer brood.

Year.	Mean temperature, degrees.	Duration, days.
1915	83.5	4.8
1916	84.6	5.3
1917	82.8	5.4

Table 8 gives a summary of the period of incubation of the Summer brood of *M. histrionica* over a period of three years. The records given show an average duration of this stage of 5.2 days, with a mean daily temperature of 83.6° F.

Fall Brood

In the Fall brood we again have a long period of incubation and one which varies greatly, not only within the season but from year to year. The length of this period in the Fall brood is much the same as it is in the Spring brood.

Table 9.—Duration of egg stage, brood—1915.

Laid.	Hatched.	Days.	Temperature.			Humidity.		
			Max.	Min.	Mean.	Max.	Min.	Mean.
1915	1915							
Aug. 6	Aug. 15	9	101.5	63	86.3	98	29	65.9
9	18	9	100	63	83.1	98	29	66.4
22	27	5	94	71.5	83.1	99	40.5	74.9
30	Sept. 4	5	91	60	74.2	100	41	73.6
Nov. 5	Nov. 17	12	92	33	71	100	25	77.6
5	21	16	92	33	67.5	100	23	76.7
5	21	16	92	33	67.5	100	23	76.7
5	21	16	92	33	67.5	100	23	76.7
17	Dec. 16	29	84	31	58.2	100	14	67.1

The longest period of incubation of this brood was 29 days, with a mean daily temperature of 58.2° F.; the shortest period of this brood was 5 days, with a mean daily temperature of 78.6° F. The average period of this brood was 12.7 days, with a mean daily temperature of 74.0° F.

Table 10.—Duration of egg stage, brood—1916.

Laid.	Hatched.	Days.	Temperature.			Humidity.		
			Max.	Min.	Mean.	Max.	Min.	Mean.
1916	1916							
Aug. 16	Aug. 21........	5	98	69	84.4	96	38	68.2
18	23........	5	101	72	85.4	97	29	66.1
23	28........	5	99	65	84.1	97	29	66.2
23	29........	6	99	65	81.7	97	29	67.7
23	31........	8	99	65	84	98	29	68.1
25	Sept. 3........	9	98	65	84.1	98	29	69.1
26	Aug. 31........	5	97	66	85.5	98	29	65.8
26	Sept. 1........	6	77	66	84.6	98	29	66
29	3........	5	98	70	84.5	98	37	70.5
30	5........	6	100	70	84.7	97	34	66.8
31	6........	6	100	71	85.2	97	34	67.1
Sept. 9	Sept. 12........	3	95	72	84.5	97	35	69
11	15........	4	101	72	85.5	97	34	68
18	26........	8	96	61	80	96	21	69.8
17	25........	8	95	61	78.6	96	21	57
21	30........	9	96	51	79	96	21	63.7
21	30........	9	96	51	79	96	21	63.7
17	25........	8	95	61	78.5	96	21	57
17	25........	8	95	61	78.5	96	21	57
17	25........	8	95	61	78.5	96	21	57
17	25........	8	95	61	78.5	96	21	57
17	25........	8	95	61	78.5	96	21	57
17	25........	8	95	61	78.5	96	21	57
17	25........	8	95	61	78.5	96	21	57
20	28........	8	96	61	79.5	96	21	64
20	28........	8	96	61	79.5	96	21	64
20	28........	8	96	61	79.5	96	21	64
20	28........	8	96	61	79.5	96	21	64
20	28........	8	96	61	79.5	96	21	64
Oct. 1	Oct. 9........	8	95	46	76	97	20	61.8
6	13........	7	95	61	79.8	97	51	60.8
15	22........	7	92	38	68.8	99	31	70.1
Oct. 23	Nov. 6........	14	90	44	68	99	22	61.5
Nov. 3	20........	17	88	24	60	105	25	67.3

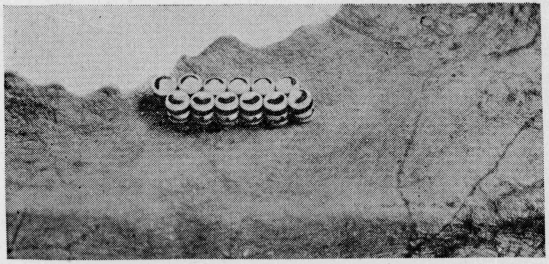
The longest period of incubation of this brood was 17 days in 1916, with a mean daily temperature of 60.0° F.; the shortest period of this brood was 4 days, with a mean daily temperature of 85.5° F. The average period of this brood was 7.5 days, with a mean daily temperature of 79.8° F.

Table 11.—Duration of egg stage, fall brood.

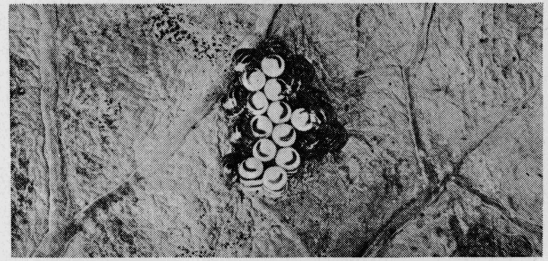
Year.	Mean temperature, degrees.	Duration, days.
1915....................................	74.0	12.7
1916....................................	79.8	7.5

The average period of incubation of the Fall brood of *M. histrionica,* as obtained from our records, is given in table 11, a period of 10.1 days, with a mean daily temperature of 76.9° F.

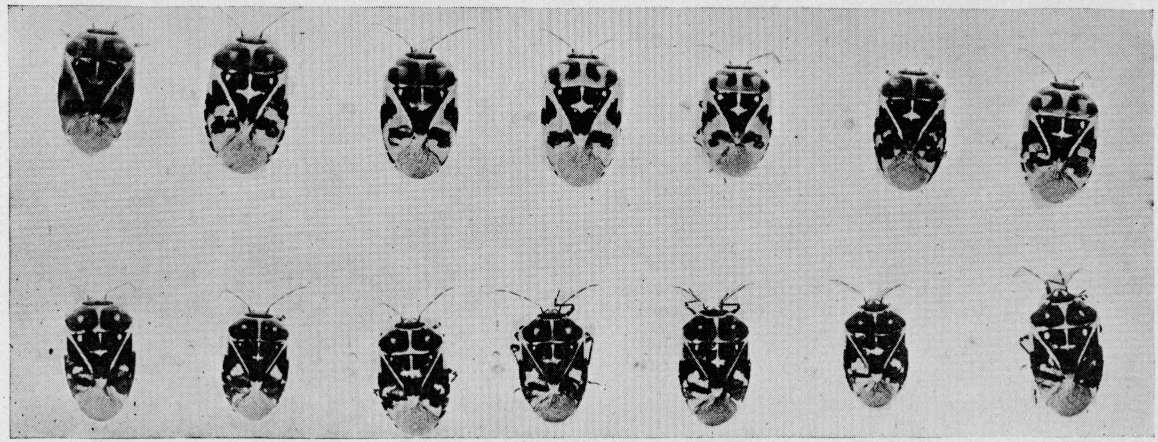
A summary of the foregoing tables gives the following periods of incubation of *M. histrionica.*



(a)



(b)



(c)

Plate 5.—(a) Eggs of the harlequin bug; (b) young just hatched, clinging to egg mass; (c) color variation in summer and over winter broods. (Original)

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Spring: 11.2 days, with a mean daily temperature of 69.9° F.
Summer: 5.2 days, with a mean daily temperature of 83.6° F.
Fall: 10.1 days, with a mean daily temperature of 76.9° F.

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Number of Moults

From the observations made on *M. histrionica*, the number of moults was always the same; season, temperature and the food supply did not alter the number, which was six, as shown in the tables that follow.

Spring Brood

Table 12.—Length of instars. Brood—1915.

Hatched.	M—1	Days.	M—2	Days.	M—3	Days.	M—4	Days.	M—5	Days.	M—6	Days.
1915	1915		1915		1915		1915		1915		1915	
April 10....	April 15	5	April 19	4	April 23	4	April 30	7	May 8	7	May 21	13
16....	22	6	29	7	May 3	4	May 10	7	13	3	23	10
17....	23	6	29	6	5	6	9	4	16	7	22	6
19....	24	5	30	6	8	8	11	3	18	7	27	9
22....	27	5	May 2	5	10	8	14	4	20	6	30	10

For this Spring brood the average lengths of instars were: first instar, 5.4 days; second instar, 5.8 days; third instar, 6.0 days; fourth instar, 4.8 days; fifth instar, 6.0 days; sixth instar, 9.6 days. The average period from hatching to maturity of this brood was 37.6 days.

Table 13.—Length of instars. Brood—1916.

Hatched.	M—1	Days.	M—2	Days.	M—3	Days.	M—4	Days.	M—5	Days.	M—6	Days.
1916	1916		1916		1916		1916		1916		1916	
Mar. 20....	Mar. 28	8	April 10	13	April 17	7	April 20	3	April 30	10	May 11	11
23....	31	8	12	12	20	8	May 2	12	May 5	3	15	10
30....	April 10	11	19	9	24	5	7	13	12	5	18	6
April 4....	12	8	20	8	28	8	8	10	16	8	22	6
4....	13	9	20	7	29	9	10	11	18	8	24	6
12....	17	5	24	7	27	3	5	8	15	10	29	14
18....	23	5	May 2	9	May 5	3	12	7	24	17	June 4	11
18....	23	5	April 29	6	8	9	22	14	27	5	May 31	4
20....	24	4	28	4	5	7	10	5	24	14	June 4	11
23....	May 2	9	May 8	6	12	4	24	12	31	7	5	5
25....	4	9	10	6	15	5	18	3	25	7	5	11
May 9....	16	7	24	8	June 1	8	June 8	7	June 15	7	18	3
9	13	4	23	10	May 29	6	4	6	12	8	16	4
12....	15	3	26	11	31	5	8	8	14	6	19	5
13....	20	7	June 5	16	June 8	3	14	6	18	4	22	4
17....	20	3	May 26	4	May 31	5	5	5	12	7	21	9
20....	25	5	31	6	June 7	7	16	9	19	3	22	3
June 5....	June 9	4	June 13	4	18	5	23	4	July 1	8	July 7	6

The average lengths of the instars of this brood were: first instar, 6.3 days; second instar, 8.1 days; third instar, 5.9 days; fourth instar, 7.9 days; fifth instar, 7.6 days; sixth instar, 7.1 days. The average period from hatching to maturity was 42.9 days.

From the records of the two years, the average lengths of the instars of the Spring brood of *M. histrionica* are: first instar, 5.8 days; second instar, 6.8 days; third instar, 5.9 days; fourth instar, 6.3 days; fifth instar, 6.8 days; and sixth instar, 8.3 days.

Summer Brood

Table 14.—Length of instars. Brood—1915.

Hatched.	M—1	Days.	M—2	Days.	M—3	Days.	M—4	Days.	M—5	Days.	M—6	Days.
1915	1915		1915		1915		1915		1915		1915	
June 24....	June 29	5	July 2	3	July 7	5	July 13	6	July 22	9	July 25	3
25....	30	5	3	3	8	5	14	6	23	9	26	3
July 2....	July 5	3	10	5	14	4	20	6	24	3	29	5
6....	10	4	13	3	18	5	22	4	Aug. 2	10	Aug. 4	2
7....	11	3	14	3	19	5	23	4	1	8	3	2
11....	14	3	17	3	23	6	27	4	4	7	9	5
13....	16	3	19	3	23	4	27	4	4	7	9	5
15....	18	3	21	3	26	5	30	4	6	6	11	5
29....	Aug. 1	2	Aug. 4	3	Aug. 8	4	Aug. 12	....	20	8	29	9

The average lengths of the instars of the Summer brood of this year were: first instar, 3.4 days; second instar, 3.2 days; third instar, 4.7 days; fourth instar, 4.7 days; fifth instar, 7.0 days; sixth instar, 4.3 days. The average length of the period from the hatching of the egg to maturity of this brood was 27.3 days.

Table 15.—Length of instars. Brood—1916.

Hatched.	M—1	Days.	M—2	Days.	M—3	Days.	M—4	Days.	M—5	Days.	M—6	Days.
1916	1916		1916		1916		1916		1916		1916	
June 12....	June 14	2	June 18	4	June 21	3	June 26	5	June 30	4	July 11	11
18....	21	3	23	2	26	3	July 4	8	July 11	7	19	8
18....	21	3	26	5	29	3	4	5	8	4	20	12
19....	21	2	23	2	30	7	9	10	13	4	22	9
20....	23	3	30	7	July 6	6	11	5	15	4	20	5
20....	23	3	26	3	June 29	3	5	6	12	7	24	12
22....	25	3	30	5	July 3	3	12	9	15	3	23	8
24....	July 1	7	July 4	3	10	6	15	5	21	6	27	6
25....	June 28	3	June 30	2	4	4	11	7	16	4	27	12
27....	July 1	4	July 6	5	9	3	12	9	17	5	27	10
28....	1	3	6	5	13	7	18	11	27	9	31	4
28....	1	3	3	2	6	3	10	7	15	6	26	11
30....	4	4	8	4	11	3	14	11	21	7	30	7
30....	4	4	6	2	9	3	14	11	23	9	Aug. 3	11
July 1....	5	4	11	6	15	6	21	15	26	5	July 31	5
4....	7	3	12	5	15	3	18	15	24	6	Aug. 2	9
5....	9	4	13	4	14	1	19	18	25	6	3	9
6....	9	3	13	4	19	6	24	5	Aug. 4	11	8	4
6....	9	3	12	3	15	3	20	5	July 25	5	7	13
6....	9	3	11	2	13	2	18	5	25	7	4	10
8....	12	8	15	4	18	3	23	5	30	7	10	11
8....	12	4	15	3	18	3	23	5	31	8	11	11
9....	12	3	15	3	19	4	25	6	31	6	13	13
9....	13	4	17	4	19	2	24	5	27	3	11	15
10....	13	3	16	3	19	3	24	5	26	2	2	7
11....	14	3	17	3	21	4	27	6	Aug. 2	6	14	12
14....	17	3	19	2	22	3	29	7	4	6	18	14
15....	17	2	19	2	27	8	Aug. 1	5	14	13	Sept. 3	20
20....	23	3	29	6	Aug. 4	6	11	7	21	10	Aug. 30	9
21....	24	3	28	4	July 31	3	7	7	18	11	31	13
22....	25	3	Aug. 1	7	Aug. 8	7	15	7	21	6	Sept. 10	18
22....	24	2	July 26	2	1	6	7	6	13	6	Aug. 27	14
24....	27	3	Aug. 1	5	8	7	11	3	17	6	30	13
24....	28	4	1	4	4	3	11	7	18	7	31	13
27....	30	3	2	3	7	5	12	5	18	6	30	12
29....	Aug. 1	3	8	5	11	3	31	20	Sept. 4	4	Sept. 9	5
Aug. 1....	4	3	6	3	11	5	17	6	Aug. 27	10	11	15
4....	8	4	12	8	15	3	22	7	30	8	11	12
6....	8	4	11	3	14	3	19	5	26	7	13	18
7....	9	3	11	2	16	5	22	6	31	9	14	14
7....	18	11	29	11	Sept. 4	6	Sept. 9	5	Sept. 16	7	23	7
9....	12	3	15	3	Aug. 19	4	Aug. 24	5	3	10	17	14
10....	12	2	15	3	18	3	27	9	2	6	16	14
13....	17	4	20	3	24	4	29	5	5	7	16	11
13....	21	8	30	9	Sept. 7	8	Sept. 12	5	19	7	26	7
17....	19	2	22	3	Aug. 25	3	Aug. 27	2	2	6	30	28
17....	20	3	24	4	28	4	Sept. 2	5	10	8	27	17

For this Summer brood the average lengths of the instars were: first instar, 3.6 days; second instar, 3.9 days; third instar, 4.2 days; fourth instar, 7.2 days; fifth instar, 6.6 days; and sixth instar, 11.3 days. The average lengths of the period from hatching to maturity of this brood was 36.8 days.

The average lengths of the instars of the Summer brood as given in tables 14 and 15 were: first instar, 3.5 days; second instar, 3.5 days; third instar, 4.5 days; fourth instar, 5.9 days; fifth instar, 6.8 days; and sixth instar, 7.8 days.

Fall Brood

Table 16—Length of instars. Brood—1915.

Hatched.	M—1	Days.	M—2	Days.	M—3	Days.	M—4	Days.	M—5	Days.	M—6	Days.
1915	1915		1915		1915		1915		1915		1915	
Aug. 18....	Aug. 21	3	Aug. 24	3	Aug. 28	4	Sept. 3	6	Sept. 6	3	Sept. 13	7
Sept. 20....	Sept. 24	3	Oct. 7	13	Oct. 11	4	Oct. 17	6	Oct. 21	4	Oct. 25	15

The average lengths of the instars of this Fall brood were: first instar, 3.0 days; second instar, 8.0 days; third instar, 4.0 days; fourth instar, 6.0 days; fifth instar, 3.5 days; and sixth instar, 5.5 days.

Table 17.—Length of instars. Brood—1916.

Hatched.	M—1	Days.	M—2	Days.	M—3	Days.	M—4	Days.	M—5	Days.	M—6	Doys.
1916	1916		1916		1916		1916		1916		1916	
Aug. 21....	Aug. 25	4	Sept. 1	7	Sept. 9	8	Sept. 14	5	Sept. 17	3	Oct. 2	15
29....	31	2	3	3	6	3	11	5	20	9	4	14
31....	Sept. 3	3	7	4	10	3	16	6	26	10	8	12
Sept. 1....	4	3	10	6	16	6	20	4	27	7	8	11
3....	6	3	10	4	15	5	23	8	29	6	13	12
5....	8	3	15	7	23	8	Oct. 2	9	Oct. 10	8	21	11
12....	16	4	23	7	30	7	1	8	13	....	Oct. 24	11
25....	29	4	Oct. 6	7	Oct. 12	10	6	....	15	....	29	14
5....	9	4	Sept. 16	7	Sept. 23	7	2	2	16	14	31	15
5....	9	4	16	7	26	6	Nov. 3	24	Nov. 18	15	Dec. 6	18
25....	29	4	Oct. 6	7	Oct. 12	6	15	....	17	....	Nov. 19	23
28....	Oct. 3	6	8	5	14	6	Oct. 25	11	23	....	4	11
Oct. 9....	12	3	18	6	22	4	Nov. 1	9	8	7	8	30
											1917	
13....	18	5	30	12	Nov. 2	3	12	10	Dec. 4	23	Jan. 28	55
15....	22	7	26	4	2	7	17	....	9	22	27	47
22....	26	4	30	4	6	7	26	20	13	17	27	....

For this Fall brood the average lengths of instars were: first instar, 3.9 days; second instar, 6.0 days; third instar, 6.0 days; fourth instar, 9.3 days; fifth instar, 12.7 days, and the sixth instar, 21.5 days. The average length of the period from hatching to maturity of this brood was 59.4 days.

The average lengths of the instars of the Fall brood, as given in tables 16 and 17, were: first instar, 3.4 days; second instar, 7.0 days; third instar, 5.0 days; fourth instar, 7.6 days; fifth instar, 8.1 days, and the sixth instar, 13.5 days.

Table 18.—Length of instars. M. histrionica.

Brood.	First instar, days.	Second instar, days.	Third instar, days.	Fourth instar, days.	Fifth instar, days.	Sixth instar, days.
Spring	5.8	6.8	5.9	6.3	6.8	8.3
Summer	3.5	3.5	4.5	5.9	6.8	7.8
Fall	3.4	7.0	5.0	7.6	8.1	13.5

Duration of Period of Maturity

The above tables deal primarily with the details of the instars, without reference to climatic conditions. The period of maturity from the hatching of the egg to the last moult is affected very much by the variations in temperature. It is very doubtful if isolated extremes in temperature affect the final length of the period as does the mean daily temperature of the entire period. A single high or a single low temperature has occurred at such a time that it is included in the observations of many individuals, but the mean daily temperature does vary with each individual record.

Spring Brood

Table 19.—Period of maturity. Brood—1915.

Hatched.	Matured.	Days.	Max.	Temperature. Min.	Mean.
1915	1915				
April 10	May 21	41	92	53	72
16	23	37	92	53	72.5
17	22	35	92	53	72.5
19	27	38	92	53	74
22	30	38	92	53	74.6

The average duration for 1915 of this period was 37.8 days, with a mean daily temperature of 73.8° F.

Table 20.—Period of maturity. Brood—1916.

Hatched.	Matured.	Days.	Temperature. Max.	Min.	Mean.
1916	1916				
Mar. 16	May 8	52	94	41	68.3
20	11	51	94	41	69.3
22	12	50	94	41	69.5
23	15	52	94	41	70
30	18	48	94	41	70.7
April 4	22	48	94	41	69.3
4	24	50	94	31	69.6
12	29	46	94	41	73.9
18	June 4	46	96	56	75.2
18	May 31	43	94	50	70.6
20	June 4	44	96	50	71.5
23	5	41	96	50	73.4
25	5	39	96	50	73.4
May 9	18	39	96	56	74.9
9	16	35	96	56	74.9
12	19	38	96	56	74.6
13	22	39	97	56	75.9
17	21	34	96	56	74.2
20	22	32	97	63	80.2
June 5	July 7	32	99	64	79.7

The observations made on this brood in 1916 extended over a period of three months, and showed some range in the length of the period of maturity. The longest period was 52 days, with a mean daily temperature of 69.1° F.; the shortest period was 31 days, with a mean daily temperature of 79.7° F. The average period of this brood was 42.9 days, with a mean daily temperature of 70.2° F.

Table 21.—Period of maturity. Brood—1917.

Hatched.	Matured.	Days.	Temperature.		
			Max.	Min.	Mean.
1917	1917				
Mar. 21	May 28	66	99	41	69.7
31	24	54	99	41	68.7
29	18	50	99	41	69.8
25	17	53	99	41	68.3
29	18	50	99	41	69.8
29	20	52	99	41	68.0

The observations made on this brood in 1917 were made over a period of three months, but there is not a decided range in the length of the period of maturity. The longest period was 66 days, with a mean daily temperature of 69.7° F.; the shortest period was 50 days, with a mean daily temperature of 69.8° F.; and the average period was 58.1 days, with a mean daily temperature of 68.7° F.

Summary

Year.	*Period.*	*Mean Temp.*
1915	37.8 days	73.8° F.
1916	42.9 days	70.2° F.
1917	58.1 days	68.7° F.

The average length of the period of the Spring brood is 46.3 days, with a mean daily temperature of 70.9° F.

Summer Brood

Table 22.—Period of maturity. Brood—1915.

Hatched.	Matured.	Days.	Temperature.		
			Max.	Min.	Mean.
1915	1915				
June 24	July 25	31	101	63	84.6
25	26	31	101	63	84.6
July 2	29	27	103	63	84.1
6	Aug. 4	29	103	63	85.1
7	3	27	103	63	85.5
11	9	29	103	63	85
13	9	27	103	63	84.9
15	11	27	103	63	85
29	29	31	103	63	83.9

There is a very little variation in the length of the period of this brood, the average being 28.7 days, with a mean daily temperature of 84.7° F.

Table 23.—Period of maturity. Brood—1916.

Hatched.	Matured.	Days.	Temperature. Max.	Min.	Mean.
1916	1916				
June 12	July 11	29	101	67	84.2
18	19	31	103	68	85.0
18	20	32	103	68	85.1
19	22	34	103	68	85.5
20	20	30	103	68	85.4
20	24	34	103	68	85
22	23	31	103	68	85.6
24	27	33	103	68	85.3
25	27	32	103	68	85.9
27	27	30	103	68	85.6
28	31	33	103	68	87.9
28	26	28	103	68	85.5
30	30	30	103	69	85.6
30	Aug. 3	34	103	69	85.5
July 1	July 31	30	103	69	85.8
4	Aug. 2	29	103	72	86.3
5	3	29	103	72	86.1
6	8	33	103	72	86.2
6	7	32	103	72	86.3
6	4	29	103	72	86.2
8	10	33	103	72	86.2
8	11	34	103	72	86.1
9	13	35	103	72	86
9	11	33	103	72	86.1
10	2	23	103	72	86.2
11	14	34	103	72	85.9
14	18	35	102	69	85.7
15	Sept. 3	49	102	65	87.1
20	30	41	102	65	85.2
21	31	41	102	65	85.1
22	Sept. 10	49	101	65	85.3
22	Aug. 27	36	101	65	84.9
24	30	27	101	65	84.7
24	31	38	101	65	89.0
27	30	34	101	65	84.8
29	Sept. 9	41	101	65	87.1
Aug. 1	11	41	101	65	85
4	11	38	101	65	85
6	13	38	101	65	84.6
7	14	38	101	65	87.0
7	23	47	101	61	81.4
9	17	39	101	65	85
10	16	37	101	65	84.7
13	16	35	101	65	84.2
13	26	44	101	61	83.4
17	30	44	101	51	83.6
17	27	41	101	61	83.4

Table 24.—Period of maturity. Brood—1917.

Hatched.	Matured.	Days.	Temperature. Max.	Min.	Mean.
1917	1917				
June 18	July 15	27	108	61	85.4
11	10	29	101	61	83.6
14	10	26	101	61	83.2
1	10	39	101	61	83.5
1	2	31	101	61	82.7
9	15	36	108	61	85.3
3	June 30	27	100	61	82.3
5	July 5	30	101	61	83.8

In this brood there was not much variation in the length of the period of maturity; climatic conditions were nearly constant. The longest period was 39 days, with a mean daily temperature of 83.5° F.; the shortest period was 27 days, with a mean daily temperature of 83.8° F.; and the average period of this brood was 30.8 days, with a mean daily temperature of 83.7° F.

Fall Brood

Table 25.—Period of maturity. Brood—1915.

Hatched.	Matured.	Days.	Temperature.		
			Max.	Min.	Mean.
1915	1915				
Aug. 18	Sept. 13	26	101	65	84.8
20	Oct. 25	35	96	44	74.7

The average period of this brood was 30.5 days, with a mean daily temperature of 78.7° F.

Table 26.—Period of maturity. Brood—1916.

Hatched.	Matured.	Days.	Temperature.		
			Max.	Min.	Mean.
1916	1916				
Aug. 21	Oct. 2	41	101	44	75.5
29	4	35	101	44	75.7
31	8	38	101	44	75.9
Sept. 1	8	37	101	44	75.6
3	13	40	101	44	76.2
5	21	46	101	44	78.2
12	31	49	101	44	78

The longest period of this brood was 49 days, with a mean daily temperature of 78.0° F.: the shortest period was 35 days, with a mean daily temperature of 75.7° F. The average period was 40.8 days, with a mean daily temperature of 76.4° F.

Summary

Year.	*Period.*	*Mean Temp.*
1915	30.5 days	78.7° F.
1916	40.8 days	76.4° F.

The average length of maturity of the Fall brood was 35.6 days with a mean daily temperature of 77.5° F.

Table 27.—Period of maturity. M. histrionica.

Spring.	Summer.	Fall.
46.3 days 72.9 °F	30.9 days 84.5 °F	35.6 days 77.5 °F

ADULTS

The harlequin bug—a striking insect—needs no description for those who have ever seen a specimen; its gay colors are sure to make lasting impression upon anyone. In fact, every description of the insect is based upon the color pattern. From a technical standpoint, this is misleading, for we know that the pattern varies greatly, with individuals and with the brood. As early as 1870 Uhler observed this variation, and his experiments showed that when insects are reared in bright light the dark blue colors predominate, and when reared in the dark the pale red colors predominate. In our work, it has become evident that highly colored individuals occur throughout the Spring and Summer broods, and the somber idividuals make up most of the over-wintering brood.

In plate 5, (c), the upper row of individuals is of the Summer generation and the lower row is of the over-wintering generation. The bugs in the upper row appear lighter; the areas most pronounced were yellow; those less pronounced were red. In the lower row the light areas were yellow. It will be observed that the amount of yellow on the bugs in the lower row is very small. It is possible to see that the somber color would be a distinct advantage to over-wintering individuals, as a matter of protection.

A liberal translation of the original description of the harlequin bug by Hahn is given herewith:

> "*Strachia histrionica.* A motely, trim bug. Rather long, black with a violet hued lusture, finely punctate; the wing covers yellowish red with a rounded edge, a long narrow streak in the middle of the same color and two such points; the scutellum with two white points and a T form, white above and a yellowish red design below, also yellowish red at the tip; the prothorax with a yellowish red background, and oblique spot below the middle and another spot below the edge; the femur has as small white spot near the anterior end; the border of the abdomen alternate black and white.
>
> "Length, 4½ lines; width, 2½ lines.
>
> "Germany. Mexico. From my collection.
>
> "The antennae are black, somewhat glossy; above the middle of the head are two white points. The beak is shiny black. The greater portion of the underside of the body is black, the thorax is finely punctate, the abdomen is smooth, shiny, dark violet. There are four small white spots on the underside of the head; the outer border of the thorax is yellowish red, oblique white spot on the outside of each tibia. The abdomen is distinctly segmented. In the middle is a round white spot, close to it on either side is a yellowish red oblique streak and still closer to the border a small white spot; the border itself is black and white alternate; the half wings are black with a violet hued change of colors."

Duration of Life

As having a possible bearing on probable control measures, a test was made to determine how long over-wintering bugs would live in the Spring without food. On February 22, 1917, five pairs of bugs were placed in an outdoor cage. These bugs had left their hibernating quarters on this warm day and were very numerous on collard plants in the garden. No bugs had been feeding previous to this day on account of the low temperatures which had prevailed. Very good protection was afforded these bugs in the cages so that they might not be killed by low temperatures. One dead male was found twenty-one days later, a female twenty-seven days later, and another thirty-three days later. A dead male and female were found after forty-four days, and all of the remaining bugs were dead in forty-seven days from the time they were placed in the cage. During the observations the bugs were quite active much of the time, and, on two dates, pairs were observed in copulation.

Generally the male dies before the female, the exception being for the male to live the longer. When the latter is the case, the difference is very little, whereas the female may live very much longer than the male, until very nearly the end of the oviposition period. In a few instances, several batches of eggs were laid after the male died. The observations on the Spring brood in 1916 are given in the following table:

Table 28.—Period between death of male and female.

Male died.	Female died.	Period, days.
June 1	June 6	5
June 2	June 4	2
June 4	June 10	6
June 5	June 12	7
June 8	June 16	8
Average, days		5.6

The observations on the Summer brood in 1917 are given below:

Table 29.—Period between death of male and female.

Male died.	Female died.	Period, days.
July 3	Aug. 23	51
July 5	July 12	7
July 9	July 30	21
July 15	Aug. 1	16
July 16	July 24	8
July 20	July 27	7
Aug. 2	Oct. 1	60
Aug. 5	Sept. 18	44
Aug. 20	Sept. 30	10
Sept. 11	Sept. 20	9
Sept. 17	Sept. 26	9
Average, days		22

The period from the date of the last oviposition until the death of the female varies much with individuals and broods, but is usually quite a few days. The observations on the Summer brood of 1916 are given in table 30.

Table 30.—Period between oviposition and death.

Last eggs laid.	Female died.	Period, days.
July 13	Aug. 1	18
July 15	Aug. 8	26
July 20	Aug. 12	21
July 25	Aug. 12	18
Aug. 2	Sept. 8	37
Aug. 7	Sept. 12	36
Aug. 10	Sept. 20	41
Aug. 13	Aug. 24	11
Aug. 15	Aug. 30	15
Aug. 20	Sept. 10	21
Aug. 31	Sept. 19	20

The longest period of this brood was 37 days; the shortest period was 11 days; the average period was 24 days.

The observations on this period in the Fall brood of 1916 are given in table 31.

Table 31.—Period between oviposition and death.

Last eggs laid.	Female died.	Period, days.
Oct. 1	Oct. 28	27
Oct. 3	Oct. 18	15
Oct. 3	Nov. 5	33
Oct. 8	Nov. 15	38
Oct. 10	Nov. 15	36
Oct. 12	Nov. 15	34

The longest period of this brood was 38 days; the shortest was 15 days, and the average period was 30 days.

Proportion of Sexes

The proportion of sexes at different seasons of the year is interesting and throws some light on that part of the life history of the insect. On March 7, 1916, the harlequin bugs were coming from a woods, where they had hibernated, to a nearby collard patch. A collection of 805 bugs was made, of which 344 were males and 458 were females. This would seem to indicate that more females than males survived the winter. But it might be taken to indicate that the females left hibernation earlier in the spring in search of food. During April, 1916. collections of bugs were made from the growing plants in the gardens, during the last ten days of the month. Of the 175 bugs collected during this period, 101 were males and seventy-four were females. The proportion of sexes at this time was the reverse of what it was when the bugs were first leaving hibernation. From May 25 to June 10, 1916, collections were made from plants in the garden of the bugs. Of the 237 bugs collected, 150 were males and eighty-seven were females. Again this is a preponderance of males, nearly twice as many. From October 10 to 20, 1916, the bugs were collected from the plants in the garden, and in all, 113 bugs were taken, of which fifty-three were males and sixty were females. As was the case upon leaving hibernation, there were more females than males at the time preceding the entrance into hibernation.

In the over-wintering cages, 1915-1916, collections were made from time to time during December, January and February. Of the 141 bugs collected, seventy-two were males and sixty-nine were females. The bugs in these cages were collected in the Fall in the garden without regard to sex.

From the above data it would appear that more females survived the winter than males, but that during the reproduction period of the year, the males are more abundant than the females.

DURATION OF LIFE CYCLE

Over-wintering Brood

Some bugs which had matured on October 9, 1915, were placed in cages, in pairs, the cage being located in shelter. Of those that survived the winter, one pair died, April 4, 1916; one pair on March 14, 1916; one pair on March 16, 1916, and one pair on April 19, 1916. From these records the average adult life of the over-wintering brood was 171 days.

Spring Brood

On May 11, 1916, pairs of bugs that had just matured were placed in cages under natural conditions in the garden. One pair died July 16, 1916; one pair July 25, 1916; one pair August 12, 1916, and one pair August 28, 1916. The records show that the average length of the adult's life in this brood was eighty-six days.

On March 8, 1917, newly collected pairs of bugs were placed in cages under natural conditions in the garden. One pair died on June 2, 1917; one pair on June 3; one pair on June 8; one pair on June 15; one pair on June 25, and one pair on July 5. From these records, the average length of the adult life of the spring brood was ninety-seven days. The average length of the adult life of the Spring brood of 1916 and 1917 was 91.5 days.

Summer Brood

During the summer, 1915, the following records were made on the length of the adult life. One pair emerged July 25 and died on November 15. One pair emerged July 27 and died November 21; one pair emerged August 8 and died November 9; one pair emerged August 9 and died October 18; and one pair emerged August 10 and died November 21. The average length of the adult life from these records was ninety-nine days.

During the Summer of 1916 the following records were made: One pair emerged May 18 and died July 9; one pair emerged May 20 and died July 16; one pair emerged May 24 and died July 20; one pair emerged May 28 and died July 20; and one pair emerged May 21 and died July 16. From these records, the average length of the adult life of this brood was fifty-four days.

The average length of the adult life of summer broods of 1915 and 1916 was 76.5 days. The above data shows the following duration of the life of the adults:

Over-wintering	171 days.
Spring brood	91.5 days.
Summer brood	76.5 days.

NUMBER OF GENERATIONS

As stated previously, the cage experiments that were conducted with the harlequin bug show that normally there are at College Station three

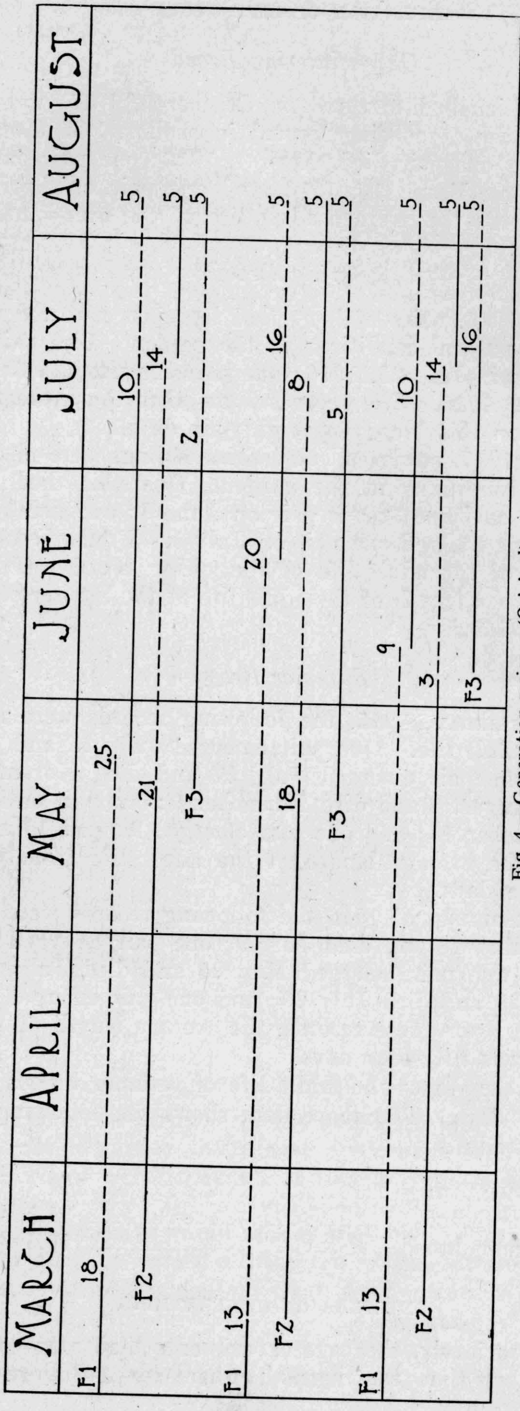

Fig. 4.—Generation series. (Original)

full generations a year. From the first born generation series it is evident that there is usually a partial fourth brood. By selecting the first born of each brood, it is possible to have the fourth brood about to maturity before low temperatures force the species to hibernation quarters. This fourth brood is to be disregarded at this latitude, however, as it must play an unimportant part in the seasonal history of the pest and the damage that may be done. Very few adults develop from the fourth brood and only adults can successfully pass through the winter at this latitude. In the southern part of the State there is every reason to suppose that four complete generations occur in a year. In the northern part of the State it is quite possible that only three complete generations occur during the year.

Figure 4 represents the data obtained from a generation study and shows the variation and overlapping in the broods. In this work the first born and last born individuals only were observed. The solid line represents the period from the time the egg was deposited until time for the following deposition, or the period of maturity of the bug. The broken line represents the period of egg deposition. The records of these series are given in this chart. On the first line is the adult over-wintering brood, the first eggs were laid on March 18 and the last eggs were laid May 25. The last batch of eggs resulted in mature bugs which laid their first batch of eggs on July 10. On the second line is the development of mature bugs from the first batch of eggs of the over-wintering adults, and these laid their first batch of eggs May 21 and the last July 14. The adults from these had not developed when the work ceased. On the third line is the development of bugs from the first batch of eggs of the second generation and a part of their third period of oviposition.

The chart gives an idea of the great variation in the development of this insect, as the three series were kept under the same conditions. From these records it is evident that for a short time eggs found in the fields may be of the last of the first generation or the first of the second generation.

Later in the season developing bugs may be from the last of the first generation or the first of the second generation. Still later in the season eggs may be those of the last born bugs of the first generation or of the first of the third generation.

FEEDING HABITS

During the spring the bugs feed extensively on the cruciferous plants with a preference shown for mustard. On this plant the feeding is confined to the young tender leaves that develop around the seed stalk. The most of the bugs are found on turnips, collards and kale. If seed stalks develop on any of these plants the bugs are found to concentrate on them, as in the case of mustard. In the experimental garden the mustard was killed by June 1 as a result of the attacks of the harlequin bug. The bugs readily leave old plants for young tender growth, even the nymphs noticeably congregate on such plants. Cauliflower was not attacked when a good supply of collards was present. Rutabaga turnips were not attacked until mustard was abandoned. Turnips do not show injury as quickly as mustard. Radishes are readily attacked and are not able to withstand the feeding of the bugs very long. With the beginning of summer, after the mustard, turnips and radishes have been killed, the bugs concentrate on kale and cauliflower. By July 10 all of the cruciferous plants in the garden were killed.

Specimens of the harlequin bug were on pepper on two dates in June. In one case the nymphs as well as adults were present. No feeding was observed by either stage, so probably the insects were on this plant merely in their migration.

Throughout June nymphs and adults were observed on okra but never have they been observed feeding. The first week in July, however, a noticeable injury was done to okra by the feeding of these bugs. During June a single adult was taken from pumpkin and also one from egg plant. These were not feeding. During July, several bugs of all stages were found on cotton, especially around the developing bolls. The feeding punctures on the bolls are readily noticeable, and apparently were injurious to the boll.

The adult bugs are known to feed on weeds in the absence of cultivated plants. Usually the weeds are available at the time of year when the cultivated plants are not present, which time varies with the locality in the State.

The comparative injury done by this insect in the spring or later in the year depends much on climate and locality. The observations made on this insect do not permit of a general statement. Along the Gulf Coast the crops suffer most from the attacks of the Spring brood, which is also the condition in the northern part of the State. In much of the remaining territory the later broods do the most of the injury.

Whenever the host plants are available the harlequin bug feeds throughout the entire summer, but in some localities during the hot, dry portion of the year, green succulent plants are not always available. Except in the extreme southern port of the State the harlequin bug does not feed throughout the winter. The general feeding of the insect ceases with the occurrence of the first frost, which may be from September 15 to November 15.

TEMPERATURE INFLUENCE

The influence of low temperatures on the feeding habits of the harlequin bug is interesting. The feeding of this insect during the spring is of much importance from an economic standpoint.

In the spring of 1915 some notes were made on the feeding activities of the insect. On March 7 very few bugs were found feeding in the garden, but on March 12 the bugs were feeding on radishes and mustard. At 3 p. m. the feeding was confined to the sunny side of the the plants. It suddenly turned cold on March 16, when but a single bug was found feeding in the garden. This was on mustard in a protected place on the plant.

On March 19 in an outdoor cage in the garden five bugs were inactive, while ten were huddled on the ground at the base of the plant. On the 19th in an outdoor cage the bugs were eating freely on mustard.

From the 19th to the 22d was a cool period, frost every night and ice two mornings. On the 22d the bugs were feeding in the garden on mustard and also in the outdoor cage. On the following days the bugs were feeding well down among the leaves. From this time until the 30th the bugs fed freely, but on the 31st no bugs were found feeding.

The climatic conditions during this period are indicated in the following table:

Table 32.—Climatic conditions.

Date.	Temperature.			Humidity.			Precip.	Char.	Dir.	Velo.
	Max.	Min.	Mean.	Max.	Min.	Mean.				
Mar. 7	49	33	41	95	50	72.5	0	clear	N	25
Mar. 8	40	33	36.5	82	63	72.5	0	cdy.	N	15
Mar. 9	38	32	35	100	74	87	.12	cdy.	E	2
Mar. 10	44	36	40	95	63	79	.03	cdy.	N	8
Mar. 11	56	34	45	96	47	71.5	0	cdy.	N	4
Mar. 12	62	46	54	86	50	68	0	P. C.	NE	4
Mar. 13	62	40	51	98	41	69.5	0	clear	N	3
Mar. 14	70	40	55	99	37	68.0	0	clear	S	2
Mar. 15	69	48	58.5	100	41	70.5	.10	clear	NW	15
Mar. 16	56	36	46	85	43	64	0	P. C.	N	20
Mar. 17	53	35	44	99	50	74.5	0	cdy.	N	8
Mar. 18	73	35	54	100	33	66.5	0	clear	S	20
Mar. 19	63	42	52.5	100	52	76	0	P. C.	NW	20
Mar. 20	55	31	43	85	33	59	0	clear	N	15
Mar. 21	49	31	41.5	82	55.5	55.5	0	clear	N	25
Mar. 22	68	34	47.5	84	57	57	0	P. C.	W	15
Mar. 23	57	27	45.5	100	67	67	0	clear	N	10
Mar. 24	73	34	55	90	64.5	64.5	0	clear	S	25
Mar. 25	82	54	68	98	74	74	0	P. C.	S	20
Mar. 26	69	55	62	99	82.5	82.5	0	cdy.	E	10
Mar. 27	58	46	52	99	83	83	0	cdy.	E	5
Mar. 28	65	51	58	98	86	86	0	cdy.	S	2
Mar. 29	77	57	67	100	78.5	78.5	0	P. C.	S	5
Mar. 30	87	54	70.5	92	34	63	0	clear	W	5
Mar. 31	61	45	53	94	34	64	0	P. C	N	25

Observations were made early in 1916 in outdoor cages and the bugs were active and feeding on the plants on January 2d, 13th, 20th; February 2d, 11th and 21st.

The climatic conditions existing on these dates were as follows:

Date.	Temperature.			Humidity.			Precip.	Char.	Dir.	Velo.
	Max.	Min.	Mean.	Max.	Min.	Mean.				
Jan. 2	78	58	68	98	72	85	0	cdy.	S	10
Jan. 13	81	48	64.5	93	56	64.5	0	clear	N	15
Jan. 20	67	37	52	100	81	90.5	0	cdy.	S	15
Feb. 2	45	31	38	99	69	84	0	cdy.	N	20
Feb. 11	75	57	66	100	54	77	0	cdy.	S	5
Feb. 21	77	39	58	100	22	61	0	clear	W	5

The feeding activity of the harlequin bug during the different parts of the day varies with the season. During the fall and spring the feeding is confined entirely to the warmest part of the day, from 10 a. m. to 3 p. m. During the summer this portion of the day is avoided for feeding purposes, the bugs seeking places protected from the heat of the sun.

LOCATION OF FOOD

The adult bugs are able to locate food in isolated places at any season of the year. The greatest migration is in the spring upon leaving the hiberating quarters. The bugs are attracted first to mustard, especially rank growth which is usually too old for greens and consequently is seldom disturbed. In the fall collards are most readily selected for feeding. For winter feeding the plants chosen are those in the most protected places, as close to a woodlot.

ADAPTIVE CAPACITY

In one instance the bugs were very numerous on a portion of a mustard bed that was not picked for greens in the spring. The growth of this mustard was very rank and served as ideal feeding quarters during early spring. Rather than feed on the mustard that was to be used for greens, the bugs spread to adjoining turnips when fresh feeding plants were needed. On these the feeding was not general over the patch but confined to the area adjoining the rank growing mustard.

On April 14 all of the mustard was cut. Twenty hours later fully seventy-five per cent of the bugs had sought new food. A few near-by stalks of volunteer mustard were severely attacked by the bugs and soon killed. Kale growing thirty feet away from the mustard attracted some bugs and a few went to turnips beyond the kale and sixty feet from the mustard. Cauliflower only fifteen feet from the mustard did not attract any of the bugs. The bugs remaining on mustard were congregated on a few partially cut off stems. All of the bugs did not leave the mustard until thirty-six hours after it was cut, at which time it was badly dried.

REPRODUCTION

Copulation

In the spring of 1915 bugs in the garden were observed in copulation for the first time on March 7. Again on the 22d, after a cool period, many of the bugs observed on the plants in the garden were in copulation. The next day but few pairs were observed, as was the case on the 30th. On the following day, however, many pairs again were observed in copulation. For the climatic conditions that prevailed during the month see table 32. Throughout April copulation may be observed at any time.

In the spring of 1916 the first pair of copulating bugs were observed in the garden on January 20. In the outdoor cages copulation of the bugs was observed on January 11th, February 2d, 11, 21st, and March 1st. The latest dates of copulation noted in the fall of 1916 were November 10th and 11th.

Period Between Maturity and Copulation

In the season of 1916 more detailed notes were made in order to determine the age of the bugs when copulation begins. The results obtained from the spring brood are shown in the following table:

Table 33.—Period between maturity and copulation.

Cage no.	Matured.	Mated.	First copulation.	Period, days.
A17	(3) May 14	May 15	May 30	15
A18	(4) May 17	May 18	May 31	20
A12	(1) Mar. 1	Mar. 8	Mar. 10	10
A15	(2) Mar. 5	Mar. 6	Mar. 15	10
A 9	(5) May 17	May 19	June 1	15
A20	(6) May 18	May 20	June 1	14

From the above it would seem that from the time of maturity to the first copulation is not so long in the early part of the season as it is in the latter part of the season. Copulation took place soon after mating in the one case when mating was delayed. The average period from the maturity of the bugs to first copulation in the spring brood of 1916 was fourteen days.

The results of the summer brood of 1916 are shown in the following table:

Table 34.—Period between maturity and copulation.

Cage No.	Matured.	Mated.	Copulation.	Period, days.
5	May 18	May 18	May 27	9
7	May 20	May 21	May 28	8
8	May 31	June 1	June 2	3
9	June 2	June 3	June 10	8
10	June 5	June 6	June 10	5

With this brood the period is much shorter in the later part of the season. The average period of this brood from maturity of the bugs to the first copulation was 6.6 days.

Table 35.—Fertility record of three females. Spring—1917.

Date.	March.			April.			May.			June.		
	A	B	C	A	B	C	A	B	C	A	B	C
1	......	......	......	......	E	......	E	E	......	......	......	......
2	......	......	......	......	......	E	......	......	......	E	......	......
3	......	......	......	E	......	C	......	......	......	......	E	......
4	......	......	......	C	......	......	......	......	......	......	......	......
5	......	......	......	......	E	......	......	......	......	......	......	......
6	......	......	......	......	......	E	E	E	......	E	E	......
7	......	......	......	E	......	......	......	C	......	......	......	......
8	......	......	......	......	......	......	C	......	......	......	......	......
9	......	......	......	C	......	......	C	......	......	......	E	......
10	......	......	......	......	E	......	......	......	......	......	......	......
11	E	......	......	......	C	E	E	......	E	......	......	......
12	......	......	......	......	......	......	C	C	C	......	......	......
13	......	......	......	......	......	......	......	E	......	......	......	......
14	......	E	......	E	......	......	......	......	......	......	......	......
15	......	......	......	C	E	E	......	C	E	......	......	......
16	......	......	......	......	C	......	......	C	C	......	......	......
17	E	E	......	E	E	......	......	......	......	......	......	......
18	......	......	E	......	......	......	......	E	E	C	......	......
19	......	......	......	......	......	E	......	C	......	......	......	......
20	......	......	......	......	E	......	C	......	......	E	......	......
21	......	C	......	E	......	E	......	E	......	......	......	......
22	E	......	......	C	C	C	E	......	......	......	......	......
23	......	......	E	......	C	......	......	E	E	......	......	......
24	......	......	......	E	E	E	......	......	......	......	......	......
25	E	E	E	......	......	C	C	C	C	C	......	......
26	C	C	C	......	......	......	......	E	......	......	......	......
27	......	E	......	......	E	E	......	......	......	......	......	......
28	......	......	......	E	E	C	E	......	......	......	......	......
29	......	E	E	C	C	......	......	E	......	......	......	......
30	E	C	C	......	......	......	......	C	......	......	......	......
31	C	......	E	......	......	......	......	E	......	......	......	......

E—eggs. C—copulation.

Fertility

The female can lay fertilized eggs for some time after the male is dead, although apparently copulation takes place before each deposition. In many cases the female in the cages has laid two or more hatches of eggs after the death of the male. In one cage the pair emerged May 10, were mated on May 13, the first eggs laid on June 2, and the male died June 7. After this date the female laid fifteen batches of eggs, all of which hatched from June 8 to August 11.

In table 35 are given the results of daily observations in three cages during the Spring of 1917. It is quite possible that all the periods of copulation were not observed, although daily notes were made on the cages. It may be said that generally copulation takes place soon after the batch of eggs has been laid and some time usually elapses between copulation and the deposition of the next batch of eggs.

Oviposition

The process of oviposition has been described in detail by Smith, and our observations only verify his description. The portion of the plant on which the eggs are laid may vary, but a protected place is always selected. The under sides of the leaves are chosen at all seasons of the year. Even in the late spring when the feeding is confined to the seed stalks of the host, the eggs are deposited on the more tender leaves of the main portion of the plant.

Age at Beginning of Oviposition

The age of the females when oviposition is started varies greatly with individuals, broods and seasons. No experiments were conducted to determine how long this could be made under adverse conditions. In nature all eggs deposited are fertile; in only a single case were infertile eggs laid.

The over-wintering females began oviposition in 1915 as early as March 13, and several batches of eggs were found in the garden on March 16. From that date the number of egg masses increased rapidly. The climatic conditions of this period are shown in table 32. On April 15, the mustard on which eggs were very abundant was cut. Most of the bugs then began feeding upon kale. In three days eggs were abundant on this host, and two days later the egg masses were more abundant on kale than they were on mustard, when it was cut.

On the Summer brood of 1915 more detailed notes were made on a few females to determine the age of the female when the first eggs were deposited. The results are shown in the following table:

Table 36.—Age of female at beginning of egg deposition.

Cage.	Matured.	First eggs.	Period, days.	Mean temperature.
1	June 3	June 16	13	82.1
2	June 5	June 23	18	82.8
3	June 6	June 20	14	82.8
4	June 8	June 22	14	83.2
5	June 23	July 20	27	85.5
6	June 24	July 13	19	85.3

The average period for this brood was 17.5 days, with a mean daily temperature of 83.9° F.

The observations made with the Fall brood of 1915 to ascertain the age of the female when the first eggs are deposited are given in the following table:

Table 37.—Age of female at beginning of egg deposition.

Cage.	Matured.	First egg.	Period, days.	Mean temperature.
8	July 27	Aug. 6	10	85.5
9	Aug. 5	Aug. 24	19	83.4
10	Aug. 9	Aug. 24	15	82.3
11	Aug. 9	Aug. 24	15	82.3
12	Aug. 10	Aug. 24	14	81.9
13	Aug. 12	Aug. 27	15	81.9

The average period of this brood was $14\frac{3}{4}$ days, with a mean daily temperature of 82.9° F.

The period of the over-wintering brood of 1915-16 as observed in cages are shown in table 38.

Table 38.—Age at beginning of egg deposition.

Cage.	Matured.	First egg.	Period, days.	Mean temperature.
5	Oct. 10–15	Mar. 10–16	152	60.6
6	Oct. 11–15	Mar. 6–16	146	60.8
7	Oct. 13–15	Mar. 14–16	152	60.3
8	Oct. 17–16	Mar. 6–16	140	60.1
9	Oct. 15–15	Mar. 10–16	146	60.5
10	Oct. 20–15	Mar. 15–16	146	60.0

The average period of this brood was 147 days, with a mean daily temperature of 60.4° F.

The observations made on over-wintering brood of 1916-1917 for the period of the age of the females when the first eggs were deposited are shown in the following table:

Table 39.—Age at the beginning of egg deposition.

Cage.	Matured.	First egg.	Period, days.	Mean. temperature.
A	Oct. 10–15	Mar. 11–16	152	60.9
B	Oct. 15–15	Mar. 18–16	156	59.9
C	Oct. 20–15	Mar. 13–16	144	59.9
D	Oct. 12–15	Mar. 10–16	150	60.5
E	Oct. 17–15	Mar. 15–16	149	60.9

The average period of this brood was 150.2 days, with a mean daily temperature of 60.4° F.

The average period from maturity to oviposition of the brood of 1915-16 and 1916-17 was 148.6 days.

The observations made in this period on the Spring brood of 1917 are given in the following table:

Table 40.—Age at beginning of egg deposition.

Cage.	Matured.	First egg.	Period, days.	Mean temperature.
17	May 11	June 1	21	77.9
18	May 14	May 31	17	77.1
19	May 15	May 30	15	76.5
20	May 18	May 28	10	76.7
21	May 20	May 29	9	79.5

The average period of this brood was 14.6 days, with a mean daily temperature of 77.5° F.

The average period between maturity of the bugs and egg deposition for the broods are as follows:

Spring	$14\frac{2}{5}$ days.
Summer	$17\frac{1}{2}$ days.
Fall	$13\frac{2}{3}$ days.
Over-winter	$148\frac{3}{5}$ days.

Period Between Copulation and Oviposition

Usually a period of from two to eight days elapses between copulation and oviposition. This period varies with the brood, season and individual. Table 35 shows the results of observations on this period of 1917. Usually copulation takes place the day following the deposition of a batch of eggs. In the early spring copulation has been observed to take place twice after which a single batch of eggs was deposited, twenty-one days later. Other cases were noted of seventeen and thirteen days between copulation and oviposition.

Period of Oviposition

In the spring of 1915 the first eggs of the over-wintering brood were found in the field on March 13. The last of the eggs were deposited by this brood May 4. The extreme length of the period was fifty-two days.

The oviposition period of the Summer brood of 1915 is shown in the following table:

Table 41.—Period of oviposition. Summer brood—1915.

Cage.	First eggs.	Last eggs.	Period, days.
1	June 16	Sept. 10	86
2	June 22	Sept. 15	85
3	June 20	Aug. 23	64
4	June 22	Sept. 5	75
5	June 23	Sept. 1	70
6	July 10	Sept. 15	67
7	June 16	Sept. 12	88
8	June 23	Sept. 31	69

The longest period of this brood was 88 days; the shortest was 66 days, and the average period of this brood was 75.5 days.

For the Fall brood of 1915 the oviposition period is shown in the following table:

Table 42.—Period of oviposition. Fall brood—1915.

Cage.	First eggs.	Last eggs.	Period, days.
9	Aug. 6	Oct. 12	68
10	Aug. 23	Oct. 3	41
11	Aug. 24	Oct. 3	40
12	Aug. 24	Sept. 26	34
13	Aug. 15	Sept. 20	36
14	Aug. 20	Sept. 30	41

The longest period for this brood was 68 days; the shortest was 34 days. The average period of this brood was $43\frac{1}{3}$ days.

In the over-wintering brood of 1915-16 the oviposition period started in the cages as early as February 2, and the last eggs found in the cages were on May 23. In the field the first eggs were not taken until April 14 on mustard.

During the fall of 1916 hatching eggs were taken from collards in the garden, on October 9, and again on October 23. Hatching eggs were taken from the cages on November 25 and 30.

The period of oviposition in the Spring brood of 1917 is shown in the following table:

Table 43.—Period of oviposition. Spring brood—1917.

Cage.	First eggs.	Last eggs.	Period, days.
A	Mar. 14	June 10	88
B	Mar. 13	June 9	88
C	Mar. 18	May 25	68
D	Mar. 15	May 30	76
E	Mar. 20	June 8	80

The longest period of this brood was 88 days and the shortest period was 68 days. The average length of this period was 80 days.

The period of oviposition in the Summer brood of 1917 is shown in the following table:

Table 44.—Period of oviposition. Summer brood—1917.

Cage.	First eggs.	Last eggs.	Period, days.
A	May 29	July 8	42
B	June 3	July 14	41
C	May 29	July 14	56
D	June 1	July 10	40
E	May 31	July 15	46

The longest period of this brood was 56 days and the shortest period was 40 days. The average period of oviposition of this brood was 45 days. The average period of oviposition of the Summer brood of 1915 and of 1917 was $60\frac{1}{5}$ days.

The average period of oviposition of all broods is as follows:

Spring .... 80 days.
Summer .... $60\frac{1}{5}$ days.
Fall .... $40\frac{1}{3}$ days.

Rate of Oviposition

The rate of oviposition of the Summer brood of 1915 is shown in the following table:

Table 45.—Rate of oviposition. Summer brood—1915.

Cage.	Eggs.	Batches.	Period.
1	261	20	86
2	138	14	85
3	142	12	64
4	89	9	75
5	68	6	70
6	79	7	67

For the Fall brood of 1915 the rate of oviposition is shown in the following table:

Table 46.—Rate of oviposition. Fall brood—1915.

Cage.	Eggs.	Batches.	Period.
9	140	12	68
10	116	10	41
11	108	10	40
12	82	7	34

The rate of oviposition in the Spring brood of 1917 is shown in the following table:

Table 47.—Rate of oviposition. Spring brood—1917.

Cage.	Eggs.	Batches.	Period.
A	237	20	88
B	260	26	88
C	228	19	68

For the Summer brood of 1917 the rate of oviposition is shown in the following table:

Table 48.—Rate of oviposition. Summer brood—1917.

Cage.	Eggs.	Batches.	Period.
A	226	19	42
B	116	14	41
C	192	16	56

Generally more time elapses between depositions of egg batches as the period of oviposition nears completion. Also the number of eggs in the batch decreases and irregular masses are more common near the end of oviposition period. The statement is usually made that normally the harlequin bug eggs are laid in regular batches of twelve each, two rows of six each. The detail observation on the egg-laying record of the females of various broods are shown in the following tables:

Table 49.—Egg laying record. Summer brood—1915.

	1		2		3		4		5		6		7	
June 16	12	r												
June 20	12	r			12	r								
June 22	12	i					12	i						
June 23			12	r					12	i				
June 25	12	r												
June 26	12	r	12	r										
June 27	12	i					12	r	12	r				
June 28					12	r								
June 30							12	i	11	i				
July 1	12	i												
July 2					12	r								
July 3			12	r			11	i						
July 4	12	i							11	i				
July 5							11	i						
July 6					12	i								
July 8			9	i					11	i				
July 11	11	i	11	i										
July 13									11	i			12	r
July 14					12	i			68					
July 16	12	i					11	i						
July 19	11	i	9	i										
July 20											7	i		
July 21			8	r	10	r	7	i						
July 22	12	r					7	i					11	i
July 23														
July 24			10	r							12	i		
July 26	12	i									12	i		
July 28											12	r	8	r
July 30	11	i	11	i										
Aug. 1					12	r					12	i	11	i
Aug. 2	10	r					6	i						
Aug. 3			11	r			89							
Aug. 5					12	r							6	i
Aug. 7	12	i									12	r		
Aug. 9			10	r	12	r								
Aug. 11	12	i									12	i		
Aug. 13					12	i							9	i
Aug. 15			8	r							12	i		
Aug. 20	12	i	7	i	12	i					79			
Aug. 27	12	i			143									
Aug. 31	12	r	8	r										

Table 50.—Egg-laying record. Fall brood—1915.

	8		9		10		11	
Aug. 6	12	r						
Aug. 11	12	i						
Aug. 13	12	i						
Aug. 16	12	i						
Aug. 23			12	i				
Aug. 24					5	i	11	i
Aug. 26					12	r		
Aug. 30					12	r	12	i
Aug. 31			12	i				
Sept. 1	12	r			12	r		
Sept. 3							11	i
Sept. 4			12	i	12	i		
Sept. 5					12	i		
Sept. 7	12	i	12	r			12	r
Sept. 9			12	r	12	i		
Sept. 11	12	r					12	r
Sept. 13			12	i	12	r		
Sept. 17	10	r	12	i				
Sept. 19							12	r
Sept. 21			8	r	10	r		
Sept. 22	12	r						
Sept. 26	12	r	12	i			12	i
Sept. 30	11	i						
Oct. 3			12	i	9	i	82	
Oct. 12	11	i	116		108			
	140							

Table 51.—Egg-laying record. Spring brood—1917.

	A		B		C	
Mar. 11	12	i				
Mar. 13			10	i		
Mar. 17	12	i	10	i		
Mar. 18					12	r
Mar. 22	12	r				
Mar. 23					12	i
Mar. 25	12	i	10	i	12	r
Mar. 27			10	i		
Mar. 29			10	r	12	i
Mar. 30	12	i				
Mar. 31					12	i
April 1			10	r		
April 2					12	r
April 3	12	r				
April 5			10	i		
April 6					12	i
April 7	12	r				
April 10			10	i		
April 11					12	i
April 14	12	r				
April 15			10	r	12	i
April 17	12	i	10	r		
April 19					12	r
April 20			10	i		
April 21	12	r			12	i
April 23			10	i		
April 24	12	i			12	r
April 27			10	r	12	r
April 28	12	i	10	r		
May 1	12	i	10	r		
May 6			10	i	12	r
May 11	12	r			12	r
May 13			10	r		
May 15					12	r
May 18			10	i	12	r
May 21			10	i		
May 22	9	i				
May 23			10	r	12	r
May 25					12	r
May 26			10	i		
May 28	15	i				
May 29			10	i		
May 31			10	i		
June 2	12	r				
June 3			10	i		
June 6	11	i	10	r		
June 9			10	r		
June 11	12	r				
June 20	10	i				

Table 52.—Egg-laying record. Summer brood—1917.

	A		B		C	
May 27	12	r	....	....	....	....
May 28	12	r	....	....	....	....
May 29	12	r	....	....	12	i
May 31	12	r	....	....	12	r
June 1	12	i	....	....	....	....
June 3	12	r	12	i	....	....
June 5	12	r	....	....	....	....
June 6	....	....	12	r	....	....
June 7	12	r	....	....	....	....
June 8	12	i	....	....	12	i
June 10	12	r	....	....	....	....
June 11	12	r	12	r	12	r
June 13	12	i	....	....	12	r
June 15	....	....	....	....	12	r
June 17	12	r	12	r	....	....
June 19	....	....	....	....	12	r
June 20	12	r	....	....	....	....
June 21	....	....	....	....	12	r
June 22	....	....	12	r	12	r
June 23	12	r	....	....	....	....
June 24	....	....	....	....	12	i
June 25	12	i	12	i	....	....
June 27	....	....	12	r	12	r
June 28	12	r	....	....	....	....
June 29	....	....	....	....	12	i
June 30	....	....	....	....	12	r
July 1	....	....	....	....	12	r
July 2	....	....	12	r	....	....
July 3	12	r	....	....	....	....
July 4	....	....	12	r	12	r
July 7	....	....	12	r	....	....
July 8	10	r	12	i	....	....
July 12	....	....	12	i	....	....
Jnly 14	....	....	12	i	12	i

PROTECTION

Undoubtedly the egg is protected by its location. Practically always the eggs are deposited on the under side of leaves of the host. On mustard sometimes the eggs are placed on the seed stem, parallel to it. It is quite probable that the glue used in cementing the eggs to the host serves as a protection, at least against severe climatic conditions. The striking color pattern of the egg is not so noticeable on the hosts as may be expected.

After hatching, the young nymphs feed in groups, usually very close to the egg mass. In this way, the young are not easily distinguished from the eggs, as shown in plate 5 (b), except at the time of the moults when the shell of the nymph is quite hard. The feeding of the nymphs is usually on the under side of the leaves in more or less protected places. If the plant is much disturbed, some of the young fall to the ground, the very young feign death, but the older nymphs seek shelter. It has been said that the gay colored pattern of this insect serves as a protection in the form of warning. If such is the case, the bugs must have a disagreeable taste.

The adults are protected chiefly by their color pattern, which serves as a warning to predacious enemies. In handling the bugs, they do not emit any odor which could be detected. Their shell is very hard and this may make them very undesirable as food to pillagers.

HIBERNATION

Entrance

The time of the entrance into hibernation by the bugs depends entirely on the temperature. Food is usually present in abundance over most of the State and the bugs continue to feed until the low temperatures force them to seek shelter. Until November 8, 1916, the bugs were numerous and active on the collards in the garden. During the preceding night the temperature dropped to 51° F., and there was .38 of an inch rainfall. On the following day, very few bugs could be found on the plants in the garden, even though the temperature had greatly increased during the afternoon. Examinations showed that many bugs were in bunches of grass close to the collards. It was apparent that the bugs were slow to leave this temporary shelter to resume their feeding. On the night of the 12th, the temperature was 31° F., and 34° F. the following night. On the 14th not a single bug could be found on the plants in the garden. Following these temperatures there was a week of warm weather but several days elapsed before many bugs ventured out to feed again.

On the morning of November 17, nearly all of the bugs were found in the rubbish around the base of the plants. A few were on the stem of the plant very near the ground, although they were not feeding. The air above the ground seemed to be warmer than farther up on the plant, which may account for the fact that a few bugs did not seek shelter and none of these bugs made an effort to escape when picked up. On the following day, no bugs were found on the plants, as the temperature of the preceding night was 36° F. During the afternoon many bugs were active on the plants, though many still remained in rubbish about the base. The following day was much warmer and many bugs were present on the plants. Some of these were feeding and one pair was observed in copulation. On November 23 a few bugs were observed on the sunny side of the plants. They were inactive and were not feeding. The following day was slightly cooler and no bugs were found on the plants, but were in the rubbish at the bottom. The following night the temperature was 35° F. and the next morning no bugs were on the plants. Many were found on bunches of grass adjoining the garden. It was not possible at any time to find in shelter close to the garden as many bugs as it was possible to find on the plants during the warm period. The additional bugs might have sought more permanent shelter in the adjoining woods, shown in plate 5. The entrance into hibernation should be considered gradual.

Stages Entering

Only adult bugs enter hibernation. The nymphs may survive late in the fall, as long as they can withstand temperatures in temporary protection in the field, but they cannot leave the field for permanent hibernation quarters. On November 16, nymphs of the last instar were taken on plants in the garden. They did not mature before cold weather killed them. At this time, the bugs on the collards were about equal in numbers of males and females. A week later, however, only females were observed on the plants. They were inactive and were not feeding.

Congregation Before Hibernation

During the late fall the bugs seemed to congregate on the host plants before going into hibernation. The approach of cold weather forces the bugs to seek feeding which is close to permanent shelter. During the warmer part of the days, the bugs are very active, many are in the air, those on the plants take flight when disturbed and any that fall to the ground immediately attempt to escape. Much time is spent in feeding.

Mortality

There is some mortality among the bugs at the time of entering hibernation. The great majority of the bugs that die at this time are undoubtedly the very old adults of the summer generation. Their vitality is low and the cold nights are enough to cause death. Sudden cold spells may kill a number of over-wintering bugs before actual hibernation takes place. However, the bugs seem to be able to foretell what temperatures are probable and seek shelter if necessary.

Duration

At this latitude there is not a true hibernation, for if the weather is sufficiently warm at any time during the winter the bugs will leave hibernation. The last week of November, 1916, was warm after the bugs had left the fields. During this time a few bugs returned to the plants although they did not feed, but the great majority remained in hibernation. The maximum temperature for this period was 81° F., the minimum temperature for this period was 52° F., and the mean daily temperature was 65° F. The first week of December was warmer, the maximum was 80° F., the minimum was 50° F., and the mean daily temperature was 70° F. More bugs were present on the plants and were feeding. At such a time the bugs leave the plants every night for temporary shelter. The three weeks of December were cold, and no bugs were found on the plants in the garden. During this period the maximum temperature was 82° F., the minimum was 20° F., and the daily mean temperature 50° F. After the first week of this period no bugs were found in the temporary shelter close to the plants. The bugs were again active during the first four days of January, 1917, with a daily mean temperature of 72° F. On the following night a frost occurred and the bugs were not seen on the plants when the mean daily temperature was 57° F. or above. Below this temperature the bugs remained in their shelter. The last three days in January were warm, a mean daily temperature of 67° F., and the bugs were quite active on the plants, though feeding very little. No bugs were noticed on February 3, with a mean daily temperature of 54° F. The mean daily temperature ranged from 60° F. to 69° F., and the bugs were quite numerous in the garden, very often feeding.

Shelter

Favorable shelter conditions are absolutely necessary to the successful hibernation of the harlequin bug. If good shelter is close to good feeding, the chances of successful hibernation are much increased. In this locality, the bugs usually leave their hibernating quarters and feed during the warm periods throughout the winter, especially when food is near. The garden was bounded by a few rows of Sudan grass and only a short distance away, perhaps 150 feet, was a wooded ravine, shown in plate 5. The Sudan grass served as an excellent temporary shelter. During the early fall when the cold spells prevailed the bugs were found in numbers in clumps of the grass. In a few cases, as many as twelve bugs were counted from one small clump. The bugs did not merely crawl down into the crown of the grass, but were found in among the roots. Any plant rubbish, such as fallen leaves, about the base of the plants serves as a temporary shelter and in the southern part of the State is sufficient protection for the insect throughout the entire winter months.

In this locality, even with a minimum temperature of 28° F., in the early fall the bugs will only seek temporary shelter. No mortality was observed under these conditions. As the season advances the low temperatures may occur, and each night fewer bugs are found in the temporary shelter in and close to the field. On December 9, 1916, the bugs were to be found in considerable numbers in the clumps of grass and they were rather active when disturbed. A few days later, after a few nights of frost, only a few bugs could be found in the grass and a week later no bugs were present. During the winter after the warm spells the bugs could be found in temporary shelter for a day or two after low temperatures again prevailed. In one instance, on December 17, 1916, twenty bugs were found under some oak leaves that had accumulated in front of a fence post. In late winter bugs were taken from temporary shelter in the collard patch where they apparently had survived during the winter.

One experiment was conducted to show the importance of shelter and feed to the successful hibernation of the harlequin bug. On November 10, 1916, a warm day when the bugs were active, five males and five females were placed in a cage without any food or shelter. Three days later, after a cold night, three females were found dead. The following day, after a night of 30° F., one male was dead; the remaining insects were on the side of the cage. On December 6, the remainder of the bugs in the cage were dead. The same number of bugs were placed in a cage with plenty of food and shelter. During the cold periods no bugs were seen on the side of the cage, as were bugs without shelter. During the warm weather the bugs were always feeding. All of these survived the winter.

The matter of shelter depends on the locality of the State. Throughout the southern section the bugs seldom seek shelter during the winter. Further north temporary shelter is always sought and permanent shelter is used but for a short time. Throughout the northern section the bugs leave the fields and seek protection in timber, buildings and trash.

Mortality

In this locality there is a considerable mortality in over-wintering individuals of the harlequin bug. On January 20, 1917, further field examination showed 25 per cent. mortality. On March 3, 1915, examination in outdoor cages showed $33\frac{1}{3}$ per cent. mortality. Another examination of the outdoor cages on March 16, 1915, revealed $16\frac{2}{3}$ per cent. mortality.

Table 53.—Mortality of the harlequin bug in outdoor cages.

Cage no....	No. 1	No. 6	No. 7	No. 9	No. 11	No. 12	No. 13	No. 15	No. 17	No. 22	Total.
No. in cage	150	150	150	100	150	100	100	150	100	100	
Nov. 17–15	5	20	5	0	6	5	5	20	3	13	82
Dec. 1–15	24	6	9	2	12	2	0	4	3	0	62
Dec. 20–15	4	3	4	0	......	0	0	......	0	......	11
Dec. 4–15	1	1	3	0	4	0	0	4	0	0	13
Dec. 31–15	2	3	3	0	0	1	0	1	0	0	10
Jan. 7–16	4	0	2	1	4	3	1	0	0	0	15
Feb. 11–16	7	6	3	10	4	1	1	7	9	0	48
Feb. 21–16	0	0	2	1	0	0	0	0	0	0	3
Mar. 13–16	0	0	0	3	17	0	0	0	0	0	20
Total died..	47	39	31	17	47	12	7	36	15	14	264
Percent died.....	.31	.26	.21	.17	.31	.12	.07	.24	.15	.14	.21

In table 53 is given the mortality record of our outdoor cages for the winter of 1916-17. The maximum mortality was 31 per cent.; the minimum was 71.2 per cent., and the average mortality was 22 per cent. It will be seen that a very heavy mortality occurs in late fall and early winter and again in late winter or early spring, the time when sudden cold spells occur.

Emergence

The time of emergence from hibernation of the harlequin bug in this locality is hard to determine because of the intermittent winter feeding. Many of the bugs do not truly hibernate in this latitude. On March 1, 1916, many bugs were found on the outside of the outdoor cages, apparently seeking the food on the inside. These bugs apparently had come from an adjoining woods. A week later hundreds of bugs were congregated around the outdoor cages.

A collection was made of 100 bugs, forty of which were males and sixty of which were females.

In the afternoon of the following day, an isolated collard patch which was surrounded by woods was visited. Here it was found that the bugs were coming from the woods on the north against a fifteen-mile-per-hour wind. The bugs could be seen in the air as far as 115 yards, flying to a height of about ten feet, although some were flying as low as five feet. The woods to the north was 200 yards away. An inspection of the border of the woods did not reveal the presence of a single bug. It was then evident that the bugs were coming from farther in the woods and examinations were made which revealed bugs in the cracks of the bark on the trunks of the larger trees. These bugs took flight upon the least disturbance. A collection of 700 bugs was made in the garden, 305 of which were males and 395 of which were females. The next day the same collard patch was visited. This time the wind was from the north and it was cooler. No bugs were in the air and those on the plants were much less active.

In the spring of 1917 the bugs left hibernation much earlier than in 1915. On February 21, 1917, the bugs were very abundant in the garden, very active, and flying if slightly disturbed. All of the bugs were feeding and some were copulating.

Wherever hibernation takes place in the State the emergence occurs from February 15 in the south to April 15 in the extreme northern part of the State.

Rehibernation

After the bugs have left their permanent winter quarters they are often forced to seek temporary shelter during the sudden cold spells in the early spring. On March 7, 1915, most of the bugs were found in the rubbish close to the plants. The day was cool and clear with a hard north wind blowing. Following this, the bugs were active for a week, when they were again forced to seek temporary shelter. They were inactive for several days while the cold weather persisted. As late as March 30, 1915, the bugs were found in temporary shelter during a cold spell when the temperature went as low as 45° F.

The hibernation period of the 1916 brood was from December 1, 1916, to February 21, 1917.

First Food

The first food of the harlequin bug is very largely a matter of available host plants. In this locality where two or three host plants are present, there is apparently some choice. Mustard is preferred in the spring, although other host plants may be present in the same garden. Radishes are often attacked early in the spring. If mustard is not available, turnips seem to be the next choice. In many other localities, cabbage is attacked early in the spring, as it is the only available host.

The individuals of the over-wintering brood usually mature from September 1 to October 1 and live until April 10 to 20 of the following spring. The bugs are very active in the field for a period before oviposition, which time is spent in feeding.

NATURAL CONTROL

CLIMATE

Climate is a natural control measure of much importance with the harlequin bug. The extreme heat prevalent through the summer serves as a considerable check on this pest. The eggs are always deposited on the under sides of the leaves at this season. By experiments conducted during July, 1915, it was found that an exposure of the eggs to the direct rays of the sun for a period of ten minutes would kill them. The results of these experiments are given in table 54.

Table 54.—Effect of heat on the eggs of the harlequin bug.

Heat, degrees F.	Exposure.	Effect.
104	5 minutes	Hatched
116	5 minutes	Hatched
116	10 minutes	Killed
116	3 minutes	Hatched
118	3 minutes	Hatched
120	10 minutes	Killed

The effect of cold on the adults has already been mentioned under the mortality of hibernated individuals. The nymphs are not able to survive much cold. In the second instar the temperature of 40° F. is fatal. The nymphs of the fourth instar do not succumb until a temperature of 32° F. is reached.

Excessive rains kill both nymphs and adults. On April 23, 1915, a rainfall was 2.95 inches; on April 24, 1 inch; on April 25, .47 inch; and on April 26, .08 inch. The total rainfall of four days was 4.5 inches. After the rain, many dead adult bugs were found. These were found mostly on the ground, but some were in the axils of the leaves. On December 8, 1915, many nymphs in several outdoor cages were drowned, although the adults survived this storm, when 2.45 inches of rain fell.

PARASITES

No evidence of a parasite of any of the stages of the harlequin bug has been found during the observations of over three years in this locality. In 1892 Morgan found a parasite of the egg of the harlequin bug to be very common in Louisiana and Mississippi, and this was determined as *Trissoleus murgantiae* Ashm. Attempts were made to establish this parasite in other States, but apparently without avail. Morgan also records the parasite, *T. podisi,* reared from the eggs of the harlequin bug.

ENEMIES

In June, 1916, several of the rearing cages were visited by the fire ant, *Solenopsis geminata* Fab. The freshly emerged nymphs were carried off by the ants but no other stage was molested. This is the only case of predacious enemies observed in our work. Lintner records *Leptoglossus phyclopus* Linn destroying the adult harlequin bug. Poultry, turkeys, geese, and ducks will not eat the harlequin bug in any stage.

ARTIFICIAL CONTROL

FALL DESTRUCTION

It is often a simple matter to destroy large numbers of bugs during the fall. At this time, they are congregating about the remains of crops and weeds, feeding some and preparing to go into hibernation. At such times the bugs may be killed by hand picking, spraying or burning. Trap shelters are not satisfactorily efficient. Their use requires peculiar attention such as would seldom be given under field conditions. Just before hibernation the bugs frequent any shelter available in the field. During the morning the bugs can be collected fron such places in very large numbers. The same conditions exist in the early spring when the bugs are forced to seek protection every night All bugs killed during the fall will mean that many less to fight the next spring when they will be scattered over the plants. The work put in at this time will prove to be an essential part in the fight against this pest.

WINTER TREATMENT

As the bugs hibernate mostly in the fields where they feed, especially during the fall, it is apparent that all the excess plant growth in and around the field should be destroyed. The remains of the last crop should be disposed of by plowing under or burning. When such material is destroyed the hibernating quarters of the bugs are gone. With such treatment the chances are much less for the insect to survive the winter. The weeds and trash around and close to the fields should be disposed of in some manner. Rank weeds should not be allowed to grow during the late fall, since they serve as protection to the bugs.

SPRING TREATMENT

It is very important in the fight against this pest to destroy the bugs early in the spring as they are leaving the hibernating quarters. This should not be delayed until egg laying has commenced. Several days elapse between the time the bugs come out in the spring and the beginning of egg laying.

CLEAN CULTURE

There are several common weeds on which this insect breeds during the early spring. They are named under the food plants. Such weeds should be kept down at all times, not only in the fields to be planted to cabbage, but in adjoining fields and specially waste places. Weeds of any kind should not be tolerated at any time upon any farm, as they serve in one way or another to keep up the supply of insect pests.

TRAP CROPS

Trap crops are those planted at such a time that they will prove attractive to a pest before and after the main crop. If well handled, a trap crop may be a very big factor in the control of the insect; if not properly handled, it simply serves as an aid to the pest. Mustard is perhaps the best trap crop to use for the harlequin cabbage bug, though turnip, kale, or cabbage may be used. These crops should be planted at such a time that they will be attractive to the insects during the spring, from the time the bugs leave their hibernating quarters until the egg laying period is over. When the bugs become very abundant on the trap crop they should be destroyed either by spraying with pure kerosene, burning, or destroying the trap crop. During the fall the trap crop may be used to a decided advantage. It should be planted so as to be attractive to the insects after the main crop has been harvested before the bugs seek hibernating quarters. The harlequin bug is not attracted to sweetened mixtures and the use of such compounds with poison is of no practical value whatever. The same may be said of the trap lights. Records of insects caught around trap lights do not show the presence of a single harlequin bug.

REMEDIAL MEASURES

HAND PICKING

If the preventive measures have been carefully followed, the number of bugs that will appear during the summer has been materially reduced. But in spite of some precautions some bugs will be present to do injury to the crops. When the bugs first appear on cabbage, hand picking is perhaps the most satisfactory means of fighting the pest. Here again, the habit of the insect of not flying readily, is decidedly in favor of those attempting to clean their fields by such a method. Reinfestation is not likely to occur. This process may appear to be expensive and tedious, but by those who have used it it is considered a satisfactory step in the fight against the pest.

SPRAYING

The spraying is not entirely satisfactory for the control of this insect. Any material now known to kill the bugs will also kill the plants upon which they are feeding. Kerosene is most used for spraying against the bugs. It is very effective when sprayed undiluted but of course kills the plants. The best time to use this material is in the destruction of the insects on a trap crop and upon crop remnants. Kerosene emulsion of 15 per cent. strength may be used to kill the young or immature bugs.

L. B. Smith reports 65 to 75 per cent. mortality of the nymphs and 45 to 50 per cent. of the adults with the following mixtures:

Nicotine sulphate, 40 per cent.	$6\frac{1}{2}$ ozs.
Fish oil soap.	8 lbs.
Water	50 gallons.

In order to obtain good results, this material must be applied under a pressure of from 175 to 200 pounds.

The harlequin bug feeds by sucking the juices of the plant, and cannot be controlled by the use of arsenical sprays, such as Paris green, London purple, and arsenate of lead. Contact sprays must be used, which means that if a bug is not hit with some of the material it is in no way injured by the application. Some persons have found the plumber's torch to be very effective in the destruction of these bugs upon trap crops and trap remnants. Under these conditions such treatment may be advisable, but the use of the torch is somewhat limited.

SUMMARY

The harlequin bug is found over the entire State of Texas. It is injurious to many garden and truck crops, including cabbage, cauliflower, collard, mustard and turnip.

The egg stage of the Spring brood was found to be 11.2 days, of the Summer brood 5.2 days, of the Fall brood 1.01 days. The period of maturity of the Spring brood was 46.3 days, of the Summer brood 30.9 days, of the Fall brood 35.6 days. The length of the adult life of the Spring brood was 91.5 days, of the Summer brood 87.7 days, and of the over-wintering brood 171.0 days.

At College Station there are three complete generations of the harlequin bug in a year, with a partial fourth brood. There was an average mortality of hibernating bugs at College Station of 22 per cent.

There were no parasites or predacious enemies observed that are of economic importance. Artificial control must be used against this pest. Such measures as fall destruction, winter treatment, spring destruction and clean culture must be used. Remedial measures consist of hand picking, and spraying.

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